SOBA 5: SECTORAL DEVELOPMENT AND MACROECONOMICS ASSESSMENT

AYEYARWADY STATE OF THE BASIN ASSESSMENT (SOBA)

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Disclaimer
"The Ayeyarwady State of the Basin Assessment (SOBA) study is conducted within the political boundary of Myanmar, where more than 93% of the Basin is situated."

TABLE OF CONTENTS

TABLE OF CONTENTS 3

ACKNOWLEDGEMENTS 5

LIST OF ABBREVIATIONS 6

EXECUTIVE SUMMARY 9

1 INTRODUCTION 18
- 1.1 The Ayeyarwady Basin in the national context 18
- 1.2 Ayeyarwady integrated river management project and the state of the basin assessment 19
- 1.3 SOBA5 scope and objectives 19
- 1.4 Approach and methodology 20
- 1.5 Caveats and limitations 20
- 1.6 Report structure 20

2 MACROECONOMICS 22
- 2.1 Introduction 22
- 2.2 Overview of Myanmar's Economy 22
- 2.3 Estimating the contribution of the Ayeyarwady Basin 25
- 2.4 Ayeyarwady Basin role in trade and investment 30
- 2.5 Conclusion 35

3 DEMOGRAPHY 36
- 3.1 Introduction 36
- 3.2 Population growth and distribution 36
- 3.3 Population movement 43
- 3.4 Conclusions 48

4 LIVELIHOODS 49
- 4.1 Introduction 49
- 4.2 Policy context 49
- 4.3 Indicators of vulnerability and resilience 49
- 4.4 Occupations and socioeconomics 69
- 4.5 Trends in rural livelihoods 74
- 4.6 Access to services 74

5 AGRICULTURE AND IRRIGATION 82
- 5.1 Introduction 82
- 5.2 Ayeyarwady Basin 84
- 5.3 Agriculture in the Ayeyarwady Basin 86
- 5.4 Food production, security and trade 91
- 5.5 Food Security 93
- 5.6 Irrigation in the Ayeyarwady Basin 94
- 5.7 Aquaculture in Ayeyarwady Basin 101
- 5.8 Livestock in the Ayeyarwady Basin 101
- 5.9 Support services 103
- 5.10 Agricultural policy options 105
- 5.11 Conclusion 107

6 FORESTRY 110
- 6.1 Introduction 110
- 6.2 Forest Cover and Forest Loss 113
- 6.3 Timber Production 126
- 6.4 Conclusions and Recommendations 136

7 MINING 139
- 7.1 Introduction 139
- 7.2 National Mineral resources and production 139

7.3 Mineral reserves and production in the Ayeyarwady Basin ... 142
7.4 Key issues in the mining sector ... 154

8 ENERGY ... 159
8.1 Introduction ... 159
8.2 Energy Consumption ... 172
8.3 Rural Electrification ... 179
8.4 National context ... 182
8.5 Conclusions ... 206

9 TRANSPORT ... 207
9.1 Outline of Transport Economic Analyses ... 207
9.2 Extent of River Networks, Draft and Other Navigability Restrictions ... 210
9.3 Summary of Findings ... 246

10 URBAN DEVELOPMENT AND MANUFACTURING ... 252
10.1 Introduction ... 252
10.2 Urban development ... 252
10.3 Urban Centres and Development Trends ... 254
10.4 Sector Environmental Issues for River Basin Planning ... 258
10.5 Conclusions ... 260
10.6 Manufacturing industry ... 261
10.7 National overview of Manufacturing industry ... 261
10.8 Manufacturing industry in the Ayeyarwady Basin ... 264
10.9 Conclusions ... 268

11 EQUITY AND DISTRIBUTIONAL ISSUES ... 269
11.1 Introduction ... 269
11.2 Access to Land and Land Tenure ... 270
11.3 Gender ... 272
11.4 Peace Building ... 276
11.5 Conclusion ... 279

12 CASE STUDIES ... 280
12.1 Introduction ... 280
12.2 Thapanzeik Hydropower Project Case Study ... 280
12.3 Sand mining ... 289
12.4 Teak Certification ... 294

13 CONCLUSION ... 299
13.1 Natural resource development at the frontier ... 299
13.2 Urbanization and export led manufacturing ... 300
13.3 Stagnation in the agricultural heartlands ... 301
13.4 Interconnections between geographical development trends ... 301

ANNEX I – AYEYARWADY BASIN EXPORT ESTIMATES ... 302

ANNEX II – METHODOLOGY FOR DEMOGRAPHIC AND RURAL LIVELIHOODS ANALYSIS ... 304

ANNEX III - HARVESTED AREAS ... 306

ANNEX IV - FOOD BALANCE SHEET ... 307

ANNEX V - FOOD SECURITY INDEX MYANMAR ... 310

ANNEX VI - MAPS ... 311

ANNEX VII – FOREST LOST DATA FOR THE AYEYARWADY BASIN ... 321

REFERENCES ... 324

LIST OF FIGURES

Figure 1 - The Ayeyarwady Basin, showing states and regions within the basin 29

Figure 2 - National GDP and growth rate (a) and GDP per capita (b) 1960 - 2015 34

Figure 3 - GDP by major sector (a) and share of GDP by major sector (b) 2000 - 2015 34

Figure 4 - Share of national (a) and Ayeyarwady Basin (b) exports in comparison 2014 42

Figure 5 - Ayeyarwady Basin and national FDI by region/state, percent cumulative 2010/2011 - 2014/2015 investment value (a) and number of projects (b) 45

Figure 6 - Population - female, male, rural, urban, and total, by HEZ 47

Figure 7 - Main national exports by value (a) and share of value (b) 2001 - 2014 49

Figure 8 - Sex ratio (males/females) in townships overlaid on hydro-ecological zone 50

Figure 9 - Sex ratio (males/females) quantiles of townships by hydro-ecological zone with outlier townships marked 51

Figure 10 - Myanmar population change rate and population 1955 - 2017 51

Figure 11 - Population growth rates for Myanmar, South Asia, East Asia, and Pacific 52

Figure 12 - Population pyramids of 2014 and 1983 compared 52

Figure 13 - Population growth rate and projections for 2014 - 2032 by state/region 53

Figure 14 - Population density 10% percentiles overlaid on hydro-ecological zone 55

Figure 15 - Reasons for migration 56

Figure 16 - Mean district net migration rate per 1,000 population in the Ayeyarwady Basin and outside (excluding Yangon) 57

Figure 17 - Net migration rate per 1,000 population by hydro-ecological zones 57

Figure 18 - Rural-urban migration flows by hydro-ecological zone, lifetime migrants by 2014 59

Figure 19 - Rural-urban migration flows, lifetime migrants as mean % of district populations in hydro-ecological zones 59

Figure 20 - Lifetime migrants from Ayeyarwady Basin hydro-ecological zones to other countries 60

Figure 21 - Total dependency ratio in townships overlaid on hydro-ecological zone boundaries 64

Figure 22 - Township mean household size overlaid on hydro-ecological zone 65

Figure 23 - Distribution and relationship between household size and dependency ratio by hydro-ecological zone 66

Figure 24 - Quantiles of % FHH in townships by hydro-ecological zone 66

Figure 25 - % FHH in townships overlaid on hydro-ecological zone 67

Figure 26 - Poverty incidence 2010 by state/region overlaid on hydro-ecological zone 68

Figure 27 - Food poverty incidence 2010 by state/region overlaid on hydro-ecological zone 69

Figure 28 - Drivers of poverty, UNICEF analysis of IHCLA poverty data 70

Figure 29 - Poverty dynamics 2005 - 2010 in state/regions covering the Ayeyarwady Basin 70

Figure 30 - Highest education attainment, % of above 25 years of age by hydro-ecological zone 73

Figure 31 - Ethnic groups and self-administered zones in the Ayeyarwady Basin 76

Figure 32 - Flood affected villages 7 July 2017 in the Ayeyarwady Basin 77

Figure 33 - Flood occurrence risk overlaid on Ayeyarwady Basin hydro-ecological zones 79

Figure 34 - Population affected by floods 2016, Relief and Resettlement Department information 80

Figure 35 - Infant, child, and under-five mortality rates 81
Figure 36 - Nutritional status of children by state/region 82
Figure 37 - Usual activities of persons, mean % of townships by hydro-ecological zone, each error bar is constructed using a 95% confidence interval of the mean 82
Figure 38 - Occupation by industry, percentage of both sexes by state/region 83
Figure 39 - LIFT Geographic zones 85
Figure 40 - Household income sources by Hilly, Dry, and Delta zones 86
Figure 41 - Sources of household income 86
Figure 42 - Land ownership and holding sizes by Zone 87
Figure 43 - Ownership of means of transportation, % households in townships overlaid on hydro-ecological zone 88
Figure 44 - Source of lighting % households in townships overlaid on hydro-ecological zone 91
Figure 45 - Source of drinking water % HHs in townships overlaid on hydro-ecological zone 92
Figure 46 - Source of non-drinking water % HHs in townships overlaid on hydro-ecological zone 93
Figure 47 - Access to safe drinking water % HHs in townships overlaid on hydro-ecological zones 94
Figure 48 - Access to safe sanitation % HHs in townships overlaid on hydro-ecological zones 95
Figure 49 - Rice export of Myanmar and other countries, 1,000 t, logarithmic scale 109
Figure 50 - Myanmar's rice export destinations, % of quantity 109
Figure 51 - Food security index Myanmar, 2017 110
Figure 52 - Density of Surface Irrigation (ha/km^2) - Ayeyarwady River Basin, Myanmar 113
Figure 53 - Fresh water withdrawal 118
Figure 54 - Water productivity 118
Figure 55 - Forest cover in Myanmar 1990 - 2015 and deforestation rate 1991 – 2015 129
Figure 56 - Forest cover and land use in the Ayeyarwady Basin 130
Figure 57 - Policy reforms and impact in the forestry sector 132
Figure 58 - Forest cover change from 2002 - 2014 134
Figure 59 - Forest loss and gain in the Ayeyarwady Basin from 2000 - 2015 136
Figure 60 - Areas showing the extent of remaining intact forest in the Ayeyarwady Basin 138
Figure 61 - Areas of forest loss in the Ayeyarwady Basin 138
Figure 62 - Forest cover change from 2002 - 2014 in the Homalin Township, Sagaing Region 139
Figure 63 - Forest cover change from 2002 - 2014 in the Hpakant Township, Kachin State 139
Figure 64 - Changes in mangrove forest cover 1978/1989/2000/2011 139
Figure 65 - Illegal flow of timber products 141
Figure 66 - Teak AAC and production plus estimated wastage and illegal extraction 142
Figure 67 - Other hardwood AAC and production plus estimated wastage and illegal extraction 142
Figure 68 - Agribusiness concessions in Ayeyarwady Basin states/regions 144
Figure 69 - Forest Cover Change 2012 - 2014 in Hukaung Valley 145
Figure 70 - Forestry value added and share of national GDP 2001/2002 - 2013/2014 147
Figure 71 - Timber exports by value (a) and volume (M m^3) Round Wood Equivalent (b) 2000 - 2013 148

Figure 72 - Teak and hardwood extraction (m3) by state/region in the Ayeyarwady Basin 149
Figure 73 - Teak and hardwood extraction in 2000 - 01 and 2014 - 15 149
Figure 74 - Area (ha) of teak plantation from 2008 - 2009 to 2015 - 2016 151
Figure 75 - Area (ha) of hardwood plantation from 2008 - 2009/2015 - 2016 152
Figure 76 - Local distribution of teak from 2008/2009 to 2015/2016 152
Figure 77 - Local distribution of hardwood from 2008/2009 to 2015/2016 153
Figure 78 - Myanmar timber product exports by volume (M m3) Round Wood Equivalent 153
Figure 79 - Priority zones for reforestation in the Ayeyarwady Basin 155
Figure 80 - Example of reforestation in the CDZ (Central Dry Zone Greening Department, 2015) 156
Figure 81 - Geological map of Myanmar, detailing the main geological provinces 161
Figure 82 - Differing estimates of value of jade exports in 2013-2014 context 164
Figure 83 - Major mining sites in the Ayeyarwady Basin 165
Figure 84 - Share of mines by state/region (a) share of mining employment by state/region (b) in 2014 166
Figure 85 - Number of mines in Ayeyarwady Basin states/regions 1995 - 2014 166
Figure 86 - Development of jade mining Hpakant, 1984 - 2014 167
Figure 87 - Jade and gemstone production in Myanmar 1995 – 2014 168
Figure 88 - Tagaung Taung nickel mine and smelting plant 170
Figure 89 - Namtu zinc slags (a) and Bawdwin lead-zinc-silver mine (b) in western Shan State 171
Figure 90 - National limestone production 1995 – 2014 172
Figure 91 - Share of mining in 2015 by areas of high certainty (a) and likely to be mined (b) 173
Figure 92 - Estimated mining area by Ayeyarwady Basin state/region in 2015, by certainty (a) and share of national total (high, medium, and low certainty; b) 173
Figure 93 - Change in mining disturbance 2002 - 2015 and change in bare land and share newly disturbed (a) and share of national newly disturbed land (b) by state/region for high certainty mining areas 174
Figure 94 - Ground disturbance due to mining, 2015 175
Figure 95 - Ground disturbance due to mining in the Uyu River Basin 2015 (high, medium, and low certainty) 176
Figure 96 - Myanmar TPEP 2000 - 2001 to 2013 - 2014 Mtoe 182
Figure 97 - Oil and gas exploration blocks in the Ayeyarwady Basin (a) and location of sedimentary basins, oil and gas fields in Myanmar 185
Figure 98 - Coal occurrences and coal basins in the Ayeyarwady Basin 187
Figure 99 - Locations of coal reserves over 10 Mt in the Ayeyarwady Basin 188
Figure 100 - Hydropower plants in the Ayeyarwady Basin, existing, under construction, and planned as of June 2017 189
Figure 101 - Installed large HP capacity in the Ayeyarwady Basin 1989 – 2017 190
Figure 102 - Solar potential in terms of direct normal irradiation (a) and potential solar PV output (b) 192
Figure 103 - Annual average wind speed in the Ayeyarwady Basin 193
Figure 104 - Energy use, energy intensity 1990 – 2014 195
Figure 105 - Total final energy consumption by major sector 2000/2001 to 2013/2014 (a) and total final energy consumption by sector and sub-sector share (%) 2013/2014 195

Figure 106 - National household energy sources for cooking, 2003 and 2015 196

Figure 107 - Household energy use for cooking nationally and in the Ayeyarwady Basin 2014 197

Figure 108 - Estimation of national fuelwood harvest in Myanmar 2000-2012 198

Figure 109 - National charcoal production and implied fuelwood use for charcoal production 199

Figure 110 - Estimated annual household fuelwood demand in the Ayeyarwady Basin 2014 (Mt) 200

Figure 111 - National household access to grid-based electricity 1990 - 2014 201

Figure 112 - Source of household lighting in the Ayeyarwady Basin by state/region and by hydro-ecological zone, 2014 202

Figure 113 - Proportion of households with grid-based electricity for lighting and cooking (%), 2014 203

Figure 114 - Comparing mini-grid and grid based electricity access in the Ayeyarwady Basin, 2014 204

Figure 115 - Power demand by sector 2000 - 2001 to 2012 - 2013 205

Figure 116 - Myanmar and selected regional countries electricity consumption and GDP per capita 205

Figure 117 - Electricity production by generation technology 2000 - 2001 to 2013 – 2014 206

Figure 118 - Installed capacity by generation technology 2000 - 2001 to 2013 - 2014 207

Figure 119 - Peak load growth, 1989 - 2014 207

Figure 120 - Demand supply gap 2009 - 2015 208

Figure 121 - T&D losses 2001 - 2014 *(World Bank, 2017b)* 208

Figure 122 - Share of national power generation capacity (a) in the Ayeyarwady Basin (b) by type, in 2015 210

Figure 123 - Cumulative installed HP capacity in the Ayeyarwady Basin, 1989 - 2017 (actual) and 2018 - 2030 212

Figure 124 - Current and planned HP plants in the Ayeyarwady Basin by hydro-ecological zone 212

Figure 125 - Existing and planned HP plants (>10 MW) in the Ayeyarwady Basin, 2017 213

Figure 126 - Current and planned cumulative reservoir storage capacity (a) and cumulative reservoir area (b) 214

Figure 127 - Reservoir area and reservoir storage capacity by hydro-ecological zone 214

Figure 128 - Power plants for multiple use and power only, by number of plants (%; a) and proportion of installed capacity (b) 215

Figure 129 - Proportion of RoR and storage HP plants by installed capacity (%) 216

Figure 130 - Source of investment by proportion of installed capacity (%) 216

Figure 131 - Proportion of HPPs by investing country, by number of projects (a) and installed capacity (b) 217

Figure 132 - Power exports from HP plants as proportion of installed capacity current and planned 217

Figure 133 - Hydropower development in Mali Hka, Naw Chang Hka, and Nmae Hka catchments (a) and reservoir inundation on the Mali Hka and N'Mai Hka Rivers (b) 219

Figure 134 - Existing and planned HP development in the Chindwin Basin 221

Figure 135 - Hydropower plants on the Dapien 223

Figure 136 - Hydropower development on the Shweli 224

Figure 137 - Hydropower development on the Nam Tabak 225

Figure 138 - Hydropower development in Myithnge, Ma Gyi, and Mu sub-basins 226

Figure 139 - Hydropower development in the Lower Ayeyarwady Basin 228

Figure 140- Cost and carbon comparison between modes, based on USA data 233

Figure 141 - Navigable Waterways ... 236
Figure 142 - Dry season water depths (m) as reported by JICA ... 238
Figure 143 - A navigation aid ... 240
Figure 144 - Ayeyarwady River Bridge at Pakokku ... 240
Figure 145 - Gantry crane and barge crane at Semeikhon ... 241
Figure 146 - Floating cranes on barges at Sagaing ... 241
Figure 147 - Sand being moved by an excavator, near Mandalay ... 241
Figure 148 - Example of excavator aboard a vessel ... 241
Figure 149 - Example of planks used for boarding and alighting ... 242
Figure 150 - Example of manual cargo handling and unsheltered storage of cargoes ... 243
Figure 151 - Freight Modal Split 1985/1986 to 2011/2012 ... 246
Figure 152 - Passenger Transport Demand (thousand trips per day) by mode versus length ... 251
Figure 153 - Coal Being Transported along the Ayeyarwady ... 256
Figure 154 - Barge Carrying Rice, with Push-Tug on Starboard ... 256
Figure 155 - Barge with partial load and push-tug ... 256
Figure 156 - Current cargo volumes at Mandalay Port ... 257
Figure 157 - Forecast capacity and throughput evolution at Mandalay Port ... 257
Figure 158 - Schematic of inland waterway traffic data in the Ayeyarwady Basin ... 259
Figure 159 - Monthly changes in vessel tonnages by revenue station ... 260
Figure 160 - Monthly changes in vessels by evenue Station – smoothed ... 261
Figure 161 - Vessels by revenue station on Ayeyarwady and Chindwin – smoothed ... 261
Figure 162 - Monthly changes in tonnages by revenue station - smoothed ... 262
Figure 163 - Tonnages by revenue station on the Ayeyarwady and Chindwin - smoothed ... 262
Figure 164 - Monthly changes in revenues by revenue station – smoothed ... 263
Figure 165 - Revenues by revenue station on the Ayeyarwady and Chindwin – smoothed ... 263
Figure 166 - Example of a small vessel in use as a cross-river ferry (1) ... 265
Figure 167 - Example of a small vessel in use as a cross-river ferry (2) ... 265
Figure 168 - Example of a small boat being used for fishing ... 265
Figure 169 - Example of a small cargo vessel in operation ... 265
Figure 170 - IWT performance by fiscal year: passenger transport ... 266
Figure 171 - IWT performance by fiscal year: freight transport ... 266
Figure 172 - Example of T Class Vessel ... 267
Figure 173 - Barge with push-tug in operation on the Ayeyarwady River (1) ... 267
Figure 174 - Barge with Push-Tug in Operation on the Ayeyarwady River (2) ... 269
Figure 175 - Ship Sailing on Ayeyarwady River (1) ... 270
Figure 176 - Ship Sailing on Ayeyarwady River (2) ... 270
Figure 177 - Passenger cruise vessels anchored in Mandalay during low season ... 271
Figure 178 - Passenger cruise vessel with sleeping compartments anchored at Nyaung-U ... 271

Figure 179 - Smaller capacity passenger cruise ships; one on left in active operation 271
Figure 180 - Larger passenger cruiser with cabins operating in low season 271
Figure 181 - Example of a small truck carrying sacks of cargo at a toll station for the Ava Bridge 274
Figure 182 - Example of a small truck carrying sacks of cargo near Ava Bridge 274
Figure 183 - Projected urban population growth, 2014 - 2040 279
Figure 184 - Population growth in Myanmar - Government of Myanmar projections 280
Figure 185 - Employment in agricultural sector selected SE Asian countries 1980 - 2016 280
Figure 186 - Urban centres and towns in the Ayeyarwady Basin 283
Figure 187 - Myanmar's Economic Corridor development plans 286
Figure 188 - Hierarchy of Urban Development Planning 287
Figure 189 - Industrial and manufacturing sub-sector value added and share of GDP 2000 – 2016 290
Figure 190 - Share of industrial and manufacturing enterprises by state/region in the Ayeyarwady Basin and nationwide (a) and by manufacturing sub-sector (b) 2014 - 2015 291
Figure 191 - Textiles, garments, and footwear export value and share of total export value 2001 - 2014 292
Figure 192 - IZs and SEZs in the Ayeyarwady Basin 294
Figure 193 - IZ enterprises in terms of investment (a), employment (b), and number (c) by major sub-sector 2016 296
Figure 194 - Share of cumulative investment by sector in Ayeyarwady Basin IZs by sub-sector (a) and by share of IZ investment (b) 2016 296
Figure 195 - Share of Ayeyarwady Basin IZ employment by sub-sector 2016 297
Figure 196 - 'Doing Business' in Myanmar - summary of business environment in comparison to other countries 2015 297
Figure 197 - Estimated deaths due to armed violence 1990 - 2015 in the Ayeyarwady Basin 308
Figure 198 - Thapanzeik dam 312
Figure 199 - Thapanzeik HPP in relation to Kyun Hla and Shwe Bo townships 315
Figure 200 - Rising Population of Yangon Region (in million) 320
Figure 201 - Sectoral growth rate of construction sector (blue) persistently above national GDP growth rate (orange) 321
Figure 202 - Housing projects (blue) and number of room supply (orange) in Yangon 321
Figure 203 - Ayeyarwady River system and areas affected by sediment mining 322
Figure 204 - Female labourers carrying sand extracts 324
Figure 205 - Illicit teak trade across China-Myanmar border 326
Figure 206 - FLEGT booklet in Myanmar 328
Figure 207 - Log inspection by FD officer 328
Figure 208 - Chief Minister of Ayeyarwady speaking at regional FLEGT VPA meeting 329
Figure 209 - Number of and distribution of districts in hydro-ecological zones 335
Figure 210 - Ayeyarwady Basin and hydro-ecological zones overlaid on State-Region-Division boundaries 336
Figure 211 - Harvested areas of crops in Myanmar (ha, logarithmic scale), 1994 - 2014 337
Figure 212 - Annual precipitation in the Ayeyarwady Basin 342
Figure 213 - Hydro-ecological zones of the Ayeyarwady Basin 343

Figure 214 - Potential agricultural land 344
Figure 215 - Paddy area in hydro-ecological zones of the Ayeyarwady Basin 345
Figure 216 - Paddy sufficiency 346
Figure 217 - Irrigation density 347
Figure 218 - Location of river lift irrigation services 348
Figure 219 - Groundwater irrigation 349
Figure 220 - Pumped Irrigation 350
Figure 221 - Livestock density 351

LIST OF TABLES

Table 1 - Real value added by sector 2000/2001 to 2014/2015 35

Table 2 - Livestock production in the Ayeyarwady Basin and nationally 2010/2011 (*Agricultural Census, 2010; CSO, 2016*) 37

Table 3 - Estimating the Ayeyarwady Basin share of value-added attributable to livestock and fisheries production 2014/2015 38

Table 4 - Ayeyarwady Basin share of hardwood production and forestry GDP (*CSO, 2016*) 38

Table 5 - National and Ayeyarwady Basin oil and gas production 2013/2014 (*EIS and Myanmar International Consulants [MMIC], 2015*) 39

Table 6 - Urban population share and estimated share of manufacturing value added 2014/2015 40

Table 7 - National GDP and estimated Ayeyarwady Basin contribution at 2014/2015 Consultants' estimates based on various sources (*constant 2010 prices*) 41

Table 8 - Methamphetamine seizures in Myanmar 2011 - 2015 (*UNODC, 2017*) 43

Table 9 - Domestic private sector investment 2010/2011 - 2012/2013 (*CSO, 2016*) 44

Table 10 - FDI in Ayeyarwady Basin states/regions and the rest of Myanmar 2010/2011 - 2015/2016 (*CSO*, 2016) 45

Table 11 - Population in the Ayeyarwady Basin by hydro-ecological zones 48

Table 12 - Sex ratio (males/females) quantiles of townships by hydro-ecological zone 51

Table 13 - Population growth rate and projections for 2015, 2020, 2025, and 2030 53

Table 14 - Population density quantiles in hydro-ecological zones 54

Table 15 - Number of townships with the five highest percentiles population densities by hydro-ecological zone and state/region 54

Table 16 - Rural-urban migration flows by hydro-ecological zone - lifetime migrants by 2014 58

Table 17 - Country of residence of former household members by district of residence of the reporting household, 2014 Census 60

Table 18 - Mean household size and total dependency ratio in hydro-ecological zones 63

Table 19 - Poverty and food poverty incidence, rural and urban 2010 in state/regions covering the Ayeyarwady Basin 68

Table 20 - Poverty dynamics 2005 - 2010 in state/regions covering the Ayeyarwady Basin 71

Table 21 - Education indicators - Myanmar 71

Table 22 - Literacy rates - male, female, urban, and rural, by hydro-ecological zone 72

Table 23 - Highest education attainment - % of above 25 years of age by hydro-ecological zone 73

Table 24 - Number of townships in hydro-ecological zones with ethnic groups 75

Table 25 - Estimated population affected by flooding in 2010 - baseline socioeconomic and hydrological scenario 78

Table 26 - Estimated population affected by flooding in 2030 - socioeconomic change scenario SSP2, climate change scenario Representative Concentration Pathways 4.5 78

Table 27 - Mean % of persons in townships by usual economic activity by hydro-ecological zone 83

Table 28 - Average size of land holdings in acres for those households that owned land, LIFT Baseline Survey (2012) 87

Table 29 - Ownership of means of transportation, mean % of households that own by hydro-ecological zone 88

Table 30 - RAI for state/regions covering the Ayeyarwady Basin 90
Table 31 - Source of drinking water mean % HHs in townships in hydro-ecological zones........ 92
Table 32 - Source of non-drinking water........ 93
Table 33 - Access to safe drinking water and sanitation mean % HHs by hydro-ecological zone 96
Table 34 - Land and water resources in Southeast Asia 97
Table 35 - River basins in Myanmar........ 97
Table 36 - Changes in holding sizes 2003-2010 98
Table 37 - Overlay of states/regions with hydro-ecological zones of Ayeyarwady basis (km^2) 99
Table 38 - Effective planted area, harvested area, yield and production of paddy in Myanmar 100
Table 39 - Planted and harvested areas, yield, and production other important crops (2015/2016)........ 101
Table 40 - Land use in the Ayeyarwady Basin and its hydro-ecological zones (km^2) 101
Table 41 - Agricultural land in the Ayeyarwady Basin in 2010 (ha) and increase from 2003 to 2010 (%) 102
Table 42 - VFV land (ha, 2010)........ 103
Table 43 - Net planted paddy area (ha, 2010)........ 105
Table 44 - Cropping pattern for full control irrigation in Myanmar, 1,000 ha, 2006 106
Table 45 - Four-wheel tractors per hydro-ecological zone of the Ayeyarwady Basin 106
Table 46 - Paddy surplus (t) and sufficiency (%), 2010........ 107
Table 47 - Myanmar food balance sheet of most important commodities, 2013 108
Table 48 - Post-harvest losses in rice 109
Table 49 - Myanmar Food Security Index 2017........ 110
Table 50 - Areas equipped for surface irrigation by source in the Ayeyarwady Basin (ha, 2016)........ 111
Table 51 - Areas equipped for surface irrigation by hydro-ecological zones of the Ayeyarwady Basin (ha, 2016) 112
Table 52 - Density of areas equipped for surface irrigation by hydro-ecological zone (ha/km^2) 114
Table 53 - Density of surface irrigation in the Ayeyarwady Basin by source (ha/km^2) 114
Table 54 - Groundwater irrigation from shallow and deep wells (ha, 2014)........ 115
Table 55 - Pumped river irrigation (ha, 2014)........ 115
Table 56 - Ongoing and planned pumped river irrigation (ha)........ 116
Table 57 - Ongoing and planned groundwater irrigation (ha)........ 117
Table 58 - WRUD water taxes for irrigation (MMK/ha) 117
Table 59 - Livestock population in the Ayeyarwady Basin and their distribution over the hydro-ecological zones, 2010........ 120
Table 60 - Livestock density in Ayeyarwady Basin hydro-ecological zones (animals/km^2, 2010) 121
Table 61 - LSUs in hydro-ecological zones, 2010........ 121
Table 62 - LSUs density in hydro-ecological zones, LSU/km^2, 2010 122
Table 63 - Extension workers in hydro-ecological zones of the Ayeyarwady Basin........ 124
Table 64 - Main forest types in Myanmar........ 129
Table 65 - Summary of intact forest loss between 2002-2014 and drivers in Ayeyarwady Basin state/regions 135

Table 66 - Total forest loss in the hydro-ecological zones of the Ayeyarwady Basin from 2000 – 2015 136
Table 67 - Total forest gain in the hydro-ecological zones of the Ayeyarwady Basin from 2000 – 2015........137
Table 68 - Agribusiness concessions in Ayeyarwady Basin states/regions 144
Table 69 - Type and area (km^2) of forest plantations in Myanmar... 150
Table 70 - Plantation of teak trees from 2008 - 2009 to 2015 - 2016.. 150
Table 71 - Plantation of hardwood from 2008 - 2009 to 2015 - 2016 151
Table 72 - Main mineral occurrences in Myanmar and approximate Ayeyarwady Basin share 162
Table 73 - Production of selected minerals in Myanmar 2009 - 2013 162
Table 74 - Current national and Ayeyarwady Basin energy resources 183
Table 75 - Oil and gas reserves and production in the Ayeyarwady Basin 184
Table 76 - Hydropower projects in the Ayeyarwady Basin 190
Table 77 - Biomass resources in the Ayeyarwady Basin and nationally 191
Table 78 - Summary of national transmission expansion plan 2013 - 2031 209
Table 79 - Location, capacity, and ownership of gas plants in the Ayeyarwady Basin in 2015 210
Table 80 - Hydropower plants in the Upper Ayeyarwady hydro-ecological zone key data 218
Table 81 - Hydropower plants in the Chindwin hydro-ecological zone key data 220
Table 82 - Hydropower plants in the Middle Ayeyarwady hydro-ecological zone key data 222
Table 83 - Hydropower plants in the Lower Ayeyarwady hydro-ecological zone key data 227
Table 84 - Navigable Length of Inland Waterways 237
Table 85 - Draft limitations by section of Ayeyarwady 239
Table 86 - Dry season draft limits.. 239
Table 87 - Port Charges (kyats per day)... 242
Table 88 - Loading and unloading charges (kyats per t) 243
Table 89 - Inland water and road haulage volumes 246
Table 90 - Ratios of Inland Water to Road Haulage Performance 247
Table 91 - Indexed Values from Nam & Win (2003/2004 = 100)... 247
Table 92 - Estimated typical journey distance, time, and speed between Yangon and Mandalay................248
Table 93 - Estimated inland water journey times between Mandalay and Yangon by direction 248
Table 94 - Estimated road freight journey times between Mandalay and Yangon 248
Table 95 - Annual operating costs for a 1,000 t barge 249
Table 96 - Annual operating costs for a truck 249
Table 97 - Current transport demand estimate..250
Table 98 - Cargo volume estimates (thousand Mt per day), 2015...251
Table 99 - Cargo volume mode share estimates (%), 2015 252
Table 100 - Cargo volume forecast estimates (thousand Mt per day), 2030 253
Table 101 - Cargo volume mode share estimates (%), 2030.. 253
Table 102 - Annual cargo volumes (Mt p.a.) by stretch of Ayeyarwady River 254
Table 103 - Annual port throughputs (Mt p.a.)... 254

Table 104 - Annual port throughputs by cargo type (thousand Mt p.a.) 255
Table 105 - Estimated current cement movements along Ayeyarwady River 256
Table 106 - Availability of Revenue Data by Revenue Office 257
Table 107 - Year-on-year change in number of vessels 258
Table 108 - Year-on-year change in tonnage of vessels 258
Table 109 - Year-on-year change in revenues 259
Table 110 - Vessel registrations in Mandalay Region as of 31 August 2017 264
Table 111 - IWT Performance by fiscal year 2007 - 2017 (millions) 266
Table 112 - Railway passenger fares 272
Table 113 - Railway freight tariffs 273
Table 114 - Myanmar Railways operating data in Mandalay, Yangon, and Pakokku Divisions, 2016 - 2017 Fiscal Year 273
Table 115 - Classification of urban centres in Myanmar 281
Table 116 - Details of Ayeyarwady Basin Upper Medium Urban Centres 282
Table 117 - Details of Ayeyarwady Basin Lower Medium Urban Centres 284
Table 118 - Development proposed for selected Economic Corridors 284
Table 119 - IZs and SEZs in the Ayeyarwady Basin 2017 295
Table 120 - Measures of inequality 2015 299
Table 121 - Demographic gender indicators by geographical region 2014 303
Table 122 - Gender disparity by socioeconomic characteristics 304
Table 123 - Gender disparities pertaining to employment and unemployment in Ayeyarwady Basin regions and states and nationally 2014 305
Table 124 - Gender gap education indicators in Ayeyarwady Basin regions and states, and national 2014 .. 306
Table 125 - Power production (GWh) from 2002 - 2003 to 2016 – 2017 312
Table 126 - Total irrigated area in Sagaing Region by district 313
Table 127 - Irrigation scheme and irrigated area 314
Table 128 - Timeline for Ywa Thi Village from 1990 - 2017 317
Table 129 - (Sagaing, Department of Fisheries) 318
Table 130 - Area and number of fish ponds in Shwe Bo and Kant Ba Lu districts 319
Table 131 - Gravel mining licences allocated in 2015 323
Table 132 - Gravel mining licences allocated in 2016 323
Table 133 - Stakeholders in sediment mining 324
Table 134 - Myanmar's exports by major commodity group and estimates of Ayeyarwady Basin contribution, 2014 333
Table 135 - Myanmar Food Balance Sheet 2013 338
Table 136 - Areas of forest and land use by hydro-ecological zone and state/regions in the Ayeyarwady Basin 352
Table 137 - Area forest types by hydro-ecological zone and state/region in the Ayeyarwady River Basin, 2014 353

Table 138 - Area forest cover(canopy cover (Cc) %) in 2015 by hydro-ecological zone and state/region in the Ayeyarwady Basin...354

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LIST OF ABBREVIATIONS

AAC	Annual Allowable Cut
AAGR	Average Annual Growth Rate
ADB	Asian Development Bank
AIDS	acquired immunodeficiency syndrome
ASEAN	Association of South East Asian Nations
ASM	artisanal and small-scale mining
bbl	barrel
bbl day^{-1}	barrel per day
CBOA	Cruise Boat Owners' Association
CDZ	Central Dry Zone
CESD	Centre for Economic and Social Development
CF	Community Forestry
CSO	Central Statistical Organisation
DHUD	Department of Housing and Urban Development
DMA	Department of Marine Administration
DoM	Department of Mines
DWIR	Directorate of Water Resources and Improvement of River Systems
EAG	ethnic armed group
EITI	Extractive Industries Transparency Initiative
EU	European Union
EUTR	European Union Timber Regulation
FAO	Food and Agricultural Organisation of the United Nations
FD	Forest Department
FDI	Foreign Direct Investment
FGD	focus group discussion
FHH	female-headed household
FLEGT	Forest Law Enforcement, Governance and Trade
FUG	Forest User Group
GAD	General Administration Department
g/capita/day	gram per capita per day
GDP	Gross Domestic Product
GW	gigawatt
GWh	gigawatt hour
ha	hectare (10,000 m^2, 2.5 acre)
HEZ	hydro-ecological zone
HH	Household
HIV	human immunodeficiency virus
hm^3	cubic hectometre
HP	hydropower
HPP	hydropower project
ICEM	International Centre for Environmental Management
IFC	International Finance Corporation
IHLCA	Integrated Household Living Condition Assessment
IHLCS	Integrated Household Living Conditions Survey
IMF	International Monetary Fund
IMR	infant mortality rate
IWMI	International Water Management Institute
IWT	Inland Water Transport
IWUMD	Irrigation and Water Utilization Department
IWVOA	Inland Waterway Vessel Owners' Association
IZ	industrial zone
JICA	Japan International Cooperation Agency
JV	joint venture

kcal/capita/day	kilo calorie per capita per day
KDNG	Kachin Development Networking Group
kg/capita/y	kilogram per capita per year
KIA	Kachin Independence Army
KII	key informant interview
kV	kilovolt
Kg	kilogram
km	kilometre
km^2	square kilometre
km^3	cubic kilomtre
LEO	Labour Exchange Office
LIFT	Livelihoods and Food Security Trust Fund
LSU	livestock unit
m^3	cubic metre (220 imperial gallons)
MADB	Myanmar Agricultural Development Bank
MBOA	Mandalay Boat Owners' Association
MCRB	Myanmar Centre for Responsible Business
MFCC	Myanmar Forest Certification Committee
MGE	Myanmar Gems Enterprise
MITT	Myanmar International Terminals, Thilawa
MJTD	Myanmar Japan Thilawa Development
M m^3	million cubic metres
MMIC	Myanmar International Consultants
MMK	Myanmar kyat (1 US$ = 1,338 MMK September 2017)
MMRD	Myanmar Marketing Research & Development
mm/y	millimetre per year
M m^3 y^{-1}	million cubic metres per year
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOECAF	Ministry of Environmental Conservation and Forestry
MOGE	Myanmar Oil and Gas Enterprise
MOH	Ministry of Health
MONREC	Ministry of Natural Resources and Environmental Conservation
Mt	million tonne
MTLAS	Myanmar Timber Legality Assurance System
Mtoe	million tonnes of oil equivalent
MW	megawatt
NBSAP	National Biodiversity Strategic Action Plan
NLD	National League for Democracy
NTFP	non-timber forest product
OECD	Organization for Economic Cooperation and Development
PEFC	Programme for the Endorsement of Forest Certification Schemes
persons/km^2	persons per square kilometre
PM	Particulate Matter
PMU	Project Management Unit
PPF	Protected Public Forests
PRC	People's Republic of China
PSC	production sharing contracts
RAI	Rural Access Index
RF	Reserved Forest
RoR	run-of-river
SEZs	special economic zones
SLORC	State Law and Order Restoration Council
SME	small and medium-sized enterprise
SOBA	State of the Basin Assessment
SOBA 1	State of the Basin Assessment 1: Hydrology
SOBA 3	State of the Basin Assessment 3: Sediments and Geomorphology

SOBA 5	State of the Basin Assessment 5: Sectoral Development and Macroeconomics Assessment
SOBA 5.1	State of the Basin 5.1 (Activity 4): Economic Valuation of Ecosystem Services in the Ayeyarwady Basin
SOE	state-owned enterprise
SPIC	China Power Investment Corporation
t	tonne
T&D	transmission and distribution
TCCM	Timber Certification Committee of Myanmar
t/ha	tonne per hectare
tkm	tonne-kilometre
TWh	terawatt hour
TWh y^{-1}	terawatt hour per year
TPEP	total primary energy production
TFES	total final energy supply
UNDP	United Nations Development Programme
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
UNODC	United Nations Office for Drugs and Crime
UN-REDD Programme	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
US$	United States Dollar
USA	United States of America
US$	United States Dollar
VFV	vacant, fallow, and virgin
VPA	voluntary partnership agreement
WHO	World Health Organization
WRUD	Water Resources Utilization Department
y	year

EXECUTIVE SUMMARY

The State of the Basin Assessment 5: Sectoral Development and Macroeconomics Assessment (SOBA 5) concentrates on developing a baseline analysis for demographics, economic sectors, and macroeconomic conditions in the Ayeyarwady Basin. The key objectives of SOBA 5 are to consolidate and enrich baseline understanding of the demographic, sectoral, and macroeconomic development character of the Ayeyarwady Basin, take stock of its status and trends, and analyse these trends to assess implications for the Ayeyarwady Basin and river basin planning. In contrast to the other packages that concentrate on natural systems, SOBA 5 is a baseline study of human populations and activities in the basin of economics, livelihoods, and subsistence. This SOBA report contains the following chapters:

1. Introduction
2. Macroeconomics
3. Demography
4. Rural livelihoods
5. Urban development
6. Agriculture and irrigation
7. Forestry
8. Mining
9. Energy
10. Transport
11. Manufacturing
12. Equity and distributional issues
13. Case studies
14. Conclusion

The following sections provide a summary of the key findings of these chapters.

Myanmar is entering a period of rapid and significant economic growth and structural change as it begins to develop an industrial market-oriented economy. During the late 1990s and 2000s, Myanmar was the beneficiary of rapid growth in the broader region, with the boom in demand for commodities and modest domestic reforms enabling some private sector development. This trend has continued into the 2010s. Myanmar's Gross Domestic Product in 2015 was approximately US$ 70.5 billion (2010 prices), up from approximately US$ 16 billion in 2000 (World Bank, 2017b). Between 2000 and 2010 the average real economic growth ran at approximately 12% and between 2010 and 2015 at approximately 8%. Growth has been accompanied by rapid structural change in the economy, as has been typical of many developing countries in the region over the last 10 to 15 years.

Economic growth has been driven largely by the industrial and services sectors, and the Ayeyarwady Basin has been central to this change. The preponderance of natural resources in the Ayeyarwady Basin means it dominates agricultural and forestry production. Onshore energy production is also an important contributor to national growth. Mineral resources concentrated in the basin, especially jade, gemstones, gold, copper, and nickel mean the mining sector is an important source of economic production in the basin. The development of the power sector has also been concentrated in the Ayeyarwady Basin, with almost all gas turbines situated in the basin, and large hydropower (HP) plants prevalent in the Middle Ayeyarwady hydro-ecological zone (HEZ). Due to the presence of the country's largest urban areas in the Ayeyarwady Basin, productive activities concentrated in and around urban areas, such as manufacturing, construction, and service sector activities, contribute an important share of the value that the basin adds.

The contribution of the Ayeyarwady Basin to exports is even more significant due to the concentration of manufacturing facilities in the basin and the importance of the mining industry, particularly of jade and gems. If illegal exports of timber, jade and gems and opium were included, this may increase the Ayeyarwady Basin export values by anywhere between US$ 13.2 - 31 billion in 2013/2014, or from over 100% to almost 500%.

The population of the Ayeyarwady Basin is estimated at approximately 33.2 million, or 64% of Myanmar's population. Of this total, 15.9 million are male and 17.3 million female, in 7.2 million households. The urban population of the Ayeyarwady Basin is 10.8 million, or 73% of Myanmar's urban population (including Yangon, located in the Ayeyarwady Basin). Sex ratio differs between townships, reflecting economic activities concentrated in some townships. For example, in Hpakant in Middle Ayeyarwady there are 174 males to 100 women due to jade mining in the area. In the Delta, townships have only 74 males to 100 women, indicating out-migration for work.

Population growth rates in state/regions that cover parts of the Ayeyarwady Basin are predicted to decline up to 2030. For example, in the Ayeyarwady Region the growth rate according to the census will be -0.07 in 2020 and -0.23 in 2025, in effect resulting in a decrease in the population of that region by approximately 130,000 people between 2015 and 2030. Population density in the Ayeyarwady Basin increases as one moves from the north in the Upper Ayeyarwady (where the township population density median is 2.2 persons per square kilometre [persons/km^2]) to the middle, Lower Ayeyarwady (99.9 persons/km^2) to the south in the Delta (median 334 persons/km^2, including Yangon region).

Rural to urban migration is rapidly changing the demographics in the Ayeyarwady Basin. From 2007 to 2014 in Myanmar, there was an increase in urban-to-urban migration from 40.5% to 47% of all migration flows, and rural-to-rural migration from 25.6% to near 30%. A large proportion of the urban-to-urban migration is between districts in or just around Yangon. Migration data at the district level (UNFPA 2014) indicates negative net migration, or out-migration, from the Ayeyarwady Basin with a mean district net migration of -21 and large variations between districts. The 2014 census recorded a total number of 6.9 million migrants in the districts in the Ayeyarwady Basin, of which 2.7 million had a rural destination and 4.1 million an urban destination. The number of emigrants from the Ayeyarwady Basin was approximately 1 million life-time emigrants in 2014 (with 421,000 in Thailand and 341,000 in Malaysia).

Overall, poverty in Myanmar has declined from 25.6% in 2009/10 to 19.4% in 2015 according to government estimations (*IHLCA, 2010***)**. Urban poverty declined from 34.6% in 2009/10 to 19.2% in 2015, while rural poverty declined from 38.5% in 2009/10 to 28.8% in 2015 according to World Bank calculations. A Poverty Dynamics report from 2010 data suggests that transitory poverty is nearly three times the size of chronic poverty, affecting 28% versus 10% of households, respectively. There are many ethno-linguistic groups in the Ayeyarwady Basin; the most predominant are Shan (present in 43 townships), Kachin (present in 31 townships), Chini (present in 27 townships), and Karen (present in 18 townships).

The report establishes key trends in rural livelihoods and compares the dependency on natural resources in the Ayeyarwady Basin to areas outsides the Basin. The summary of these results include:

- **Dependency on natural resources** - significantly lower (mean 51%) in the Ayeyarwady Basin compared to townships outside the Ayeyarwady Basin (mean 60%);
- **Mean household sizes** - smaller in the Ayeyarwady Basin (mean 4.46) than in townships outside the Ayeyarwady Basin (mean 4.64), and differ significantly between HEZs (Upper Ayeyarwady [5.56], Chindwin [4.9], Middle Ayeyarwady [4.5], Lower Ayeyarwady [4.0], and in the Delta [4.2];
- **Female-headed households** - townships in the Ayeyarwady Basin are two percentage points higher (mean 24.3%) compared to townships outside the Ayeyarwady Basin (mean 22.3%);
- **Access to grid electricity** - on average higher in Ayeyarwady Basin townships (mean of 34% of households) compared to townships outside the Ayeyarwady Basin (26%);
- **Safe drinking water** - approximately 75% of households in the Ayeyarwady Basin had access to safe drinking water in 2014, except in the Upper Ayeyarwady HEZ where only 26% have access;
- **Ownership of transportation assets** - the mean percentage of households in the Ayeyarwady Basin that own bicycles (33%), bullock carts (26%), canoes or boats (3.7%), motorcycles or mopeds (38%) and cars or trucks, four wheel tractors or motorboats (less than 5%);
- **Access to services** - the Rural Access Index in Myanmar calculated by the Asian Development Bank indicated that state/regions in the Ayeyarwady Basin range from a low of 11% in Chin state to a high of 61% in Mandalay region.

Child health, quality of life, and quality of health care services are important indicators of socioeconomic development. A state/region sample-based survey in 2015- 2016 found that mortality under five-years was highest in Chin State, at 104 deaths per 1,000 live births, while infant mortality was highest in Bago Region, at 80 deaths per 1,000 live births.

The Ayeyarwady Basin encompasses 66% of the total workforce in Myanmar according to the 2014 census. The mean percentage of 'own account workers' (farmers, fishers, handicrafts, etc.) in townships is approximately 24 - 26% in all HEZs, except in the Delta where only 16% of economically active people are 'own account workers'. The Livelihoods and Food Security Trust Fund Baseline Survey 2012 covers three zones (hilly, dry and delta/coastal areas) and found that agriculture and related activities, including casual labour in agriculture, were by far the most important economic activities for most households. Casual labour in agriculture was the most common source of income of households in the Dry Zone and in the Delta, and together with sale of other cereals, the most important source of income in the Hilly Zone.

Of the total population in the Ayeyarwady Basin, 32.5% (approximately 11 million) live in urban centres. Yangon (population 4.8 million), and Mandalay (population 1.4 million) account for 56% of this urban population. Most of the 168 urban centres throughout the Ayeyarwady Basin are relatively small, and only 10 urban centres have over 100,000 inhabitants. There are 116 urban centres with a population of 25,000 or less and 50 with less than 10,000 people.

Urban development in the Ayeyarwady Basin is characterised by inadequate investments in urban infrastructure and services. Due to insufficient investment in recent years, Myanmar's transportation infrastructure lags behind regional benchmarks, hindering access to markets and social services. The urban transport issues in the major urban centres, particularly Yangon and to a lesser extent Mandalay, are such that if current trends continue unchecked, Yangon's urban transport could become a major constraint on national economic growth. The environmental issues identified for planning in the Ayeyarwady Basin include: land use and effluent discharge permitting; watershed and river front projection, especially in flood-prone urban areas; and water allocation planning to manage sectoral and geographical trade-offs in water availability.

Irrigation, along with flood protection in coastal areas is therefore of vital importance to improve agricultural production for domestic food supply. The Ayeyarwady Basin has ample land and river water resources, but rainfall is unevenly distributed; thus, irrigation is essential for crop production in the dry areas and supplementary irrigation is needed in wet areas to even out the dry spells. There is still unused land available to extend the agricultural area and make up for the loss of agricultural land due to infrastructure development and urbanization. These lands, and much of the existing land, need improvement in access and electrification. Further farm mechanization, especially for paddy harvesting, drying, and milling, is needed to reduce losses and improve product quality. Limited agricultural support services, especially provision of seed and credit, are inhibiting the agricultural sector.

There are many significant environmental issues associated with the agricultural sector the Ayeyarwady Basin, given the sector's close reliance on natural resources and its role in modifying natural systems to improve productivity. Environmental issues include: deforestation from conversion to farmland (this may include agro-forestry plantations, intensification of swidden cycles, or other small scale conversation); land degradation from water erosion from the cultivation of steeply sloping land and unsuitable cropping patterns in some circumstances; land desertification as a result of deforestation, wind, and water erosion, and the salinization of soils in the dry zone; salinization in the dry zone associated with the evapotranspiration of saline groundwater or irrigation water leaving a salt crust on the soil surface; salinization in coastal areas due to ingress of salt water, storm surges, tides, and infiltration via the groundwater; drought and irregular rainfall; flooding; and water pollution from agricultural activities.

Key issues for agriculture vary by HEZ and states/regions in the Ayeyarwady Basin. In the upper reaches of the catchment in Kachin state, Sagaing region, and some areas of Shan State, deforestation due to clearing for various agricultural activities is important. Related to this, increased incidence and intensity of agriculture on sloping land is a growing issue. Both deforestation and the expansion of agriculture on sloping land lead to erosion, land degradation, and flooding. Lower in the catchment in the Dry Zone, agricultural issues relate to variability in water availability and soil erosion. Riverine flooding is an important constraint on agriculture in some Dry Zone areas. The coastal and estuarine areas face issues of saline intrusion, as well as riverine and coastal flooding. Recent flood events in the Ayeyarwady Basin may help explain recent stagnation in the agricultural sector. These risks are increased through the loss of mangrove forest.

The Chindwin HEZ is dominated by forest cover and more intensive agriculture is practiced where conditions allow in valley bottoms and other flat areas, where wet rice and other crops can be cultivated. However, swidden agriculture dominates and much of the forest is already degraded. There is anecdotal evidence that swidden cycles have shortened in this river basin, and there is evidence of a change to sedentary agriculture - for example through the development of terrace systems in Chin State. Key issues are likely to be rapid onset flooding, a lack of infrastructure to support agriculture (such as roads and irrigation infrastructure), and continuing forest degradation and loss. Landslides and soil erosion are also likely to be issues in hilly areas of the basin.

Forestry represents a relatively small and declining share of Gross Domestic Product due to very high growth in the industrial and service sectors, and in part due to declining productivity of the remaining forest. Timber and wood products still maintain a sizable share in export revenues and remain an important source of foreign exchange earnings. There are major discrepancies in the trade data surrounding Myanmar's timber product which make it difficult to analyze the situation in-depth. Illegally exported timber typically smuggled across the border to China by road is not accounted for in the official statistics.

Myanmar has significant forest resources; approximately 44.5% (290,000 square kilometres [km^2]) of the land area of Myanmar (676,000 km^2) was forested in 2015. The Ayeyarwady Basin has high areas of closed (or intact) forest with 40.8% of closed forest (26,395.5 km^2) remaining in the Upper Ayeyarwady HEZ, and the largest remaining intact forests in Kachin state(51,234 km^2), Chin state (13,384 km^2), and Sagaing region (31,916 km^2). Myanmar currently has the third highest deforestation rate in the world, behind Indonesia and Brazil, and has lost more than 54,600 km^2 of forest each year since 2010. The forest loss not only presents concerns for the long-term sustainability of the forestry, but also entails broader environmental consequences.

Deforestation and degradation of existing forests remains a critical issue in Kachin State and Sagaing Region in the Ayeyarwady Basin. This is mainly due to illegal and legal timber extraction, which is facilitated through the development of areas cleared for plantation and extensive mining activities (International Finance Corporation et al., 2017). The Myanmar Forest Cover Change (2002 - 2014) estimated the largest losses of intact forest in the Ayeyarwady Basin were reported in Shan state (6,326 km^2 or 26%), Sagaing region (2,798 km^2 or 8%), and Kachin state (2,090 km^2 or 4%; Bhagwat et al., 2017). Mangrove cover in the Ayeyarwady Delta declined significantly from 2,747.89 km^2 in 1980 to 450.48 km^2 in 2013, with rice production accounting for 87.6% of mangrove deforestation between 2000 and 2012 (Richards and Friess, 2016).

One of the most significant drivers in the conversion of forest to non-forest uses has been the clearing of forest for potential use for agriculture. The agribusiness concessions allocated within forests between 2010 and 2013 largely resulted in forest conversion and timber production. Evidence suggests that these concessions were used for the extraction of timber rather than to develop plantations, as by the end of the period only approximately 25% of the land allocated for agribusiness concessions had been planted with crops (Woods, 2015). Most of the agribusiness concessions were granted in Kachin State (7,676.7 km^2) and only 18.9% had been planted, while in Sagaing Region 2,158.6 km^2 ha had been allocated with 32.3% planted. The other main drivers of forest loss in the Ayeyarwady Basin are:

- Illegal logging;
- Unsustainable harvesting of timber;
- Swidden agriculture;
- Production of fuelwood and charcoal; and
- Timber extracted from the clearing of land for roads and other infrastructure, i.e., HP, mining, special economic zones.

Recent policy reforms in the forestry sector, including a bilateral agreement with the People's Republic of China to stop illegal cross-border trade and logging bans, have have been successful in reducing the extraction of teak and hardwood. The volume of teak and hardwood extracted from forests and plantations in the Ayeyarwady Basin reduced from approximately 1,176,222 cubic metres (m^3) in 2012 - 2013 to 546,428 m^3 in 2015 - 2016. However, these figures do not capture illegal logging. In 2015 - 2016 approximately 692,066 m^3 of teak and hardwood were extracted in Myanmar with 84% (546,428 m^3) extracted from states/regions of the Ayeyarwady Basin, mostly from Kachin state, Sagaing region, and Mandalay region. The Government of Myanmar has also committed to implementing a 30-year National Forest Master Plan (2002 - 2031) that sets goals of achieving: 30% of the land area within the permanent forest estate, and 10% of the land area within protected areas by the year 2030.

The increased interest and investment in establishing teak plantation was a result of declining harvestable area in natural teak forests and deteriorating quality of natural grown teak. To maintain sustainable yield of timber and forest products, natural forest regeneration and artificial forest plantation have been carried out in Myanmar. From official government figures, the area of teak plantation increased by 497.23 km^2, from 3,341.78 km^2 in 2008 - 2009 to 3,839 km^2 in 2015 - 2016, with 5.532 million new teak trees planted. The area of hardwood plantation increased by 156.87 km^2, from 4,813.29 km^2 to 4,971.97 km^2 in 2015 - 2016, with 1.765 million hardwood trees planted.

Myanmar is highly dependent on ecosystem services and products, with 66% of the population working in agriculture, and much of the rural work force involved in natural resource dependent activities including fishing, mining, and forestry. A study in 2012 found that the current annual value of forest ecosystem services is estimated to be US$ 7.3 billion (Emerton and Aung, 2013). Approximately 85% (US$ 6 billion) comes from forest ecosystem services that maintain the productivity of other sectors, add value to their output, and help them to avoid costs, losses, and damages. An important but less visible service provided by forests is watershed protection. Recognising the value of forest ecosystems, the government has prioritised three zones in the Ayeyarwady Basin for reforestation: 1) Central Dry Zone, 2) Bago Yoma, and 3) Ayeyarwady Delta.

Mining is an important and growing part of the economy in Myanmar and the Ayeyarwady Basin. The country has a complex geology giving rise to a varied and abundant array of mineral deposits. Of these, perhaps the most well-know and important are the jade tracts of the Upper Chindwin around Hpakant, and the ruby and precious stone tracts around Mogok in the Mandalay Region. The Ayeyarwady Basin holds many other important mineral deposits including copper, nickel, lead, zinc, silver, gold, and iron, as well as industrial minerals, construction materials, and mineral fuels. Deposits of global significance include the jade and ruby tracts, the copper at Monywa, and the lead-zinc-silver deposits at Bawdwin.

Mining in the Ayeyarwady Basin has expanded rapidly over recent years due to production of many minerals, including copper, lead, nickel, and limestone. This is explained by the development of several large mining projects in the basin during the 2000s, which after years of development are now starting production. In the case of limestone and other construction materials, the recent boom in production is probably largely as a result of rapid growth in demand for construction materials.

Production of jade and gemstones shows a decline in recent years, however only 20 - 40% of production is declared. This may be the result of increased stockpiling, legislative changes, or declines in demand. However, only an estimated 20 - 40% of production of jade and gemstones is declared, suggesting that official figures miss approximately 60 - 80% of production. Anecdotal evidence from mining locations suggest an up-scaling of mining activity and increased use of heavy equipment.

Official figures on mining production in the Ayeyarwady Basin are only half the story, and most mining activity is artisanal or small-scale. Artisinal and small-scale mining (ASM) is ubiquitous throughout the basin; hundreds of thousands of pickers look for jade and gemstones in the spoil heaps of Hpakant and Mogok. Small gold mines are dotted throughout Mandalay Region and western areas of Shan State, and the mining of alluvial gold deposits is a common sight along rivers and elsewhere. Concrete figures for the extent of ASM are rare but mining of this type is likely an important source of seasonal income for many people in the Upper Ayeyarwady, Middle Ayeyarwady, and Chindwin basins. Key mining areas attract considerable in-migration from elsewhere.

Better evidence of mining expansion throughout the basin is given through the analysis of remote sensing data from 2002 - 2015. This shows the large scale of mining in the Ayeyarwady Basin, and the figures suggest that mining directly affects more than 74,000 hectares. Nationally, the Ayeyarwady Basin accounts for approximately 87 - 88% of mining activity, with Kachin state, Sagaing region, and Mandalay region together accounting for 84% of the national figure. Much of this is concentrated in the Chindwin River Basin and around Mandalay region. This evidence also demonstrates rapid expansion of activity in the sector.

The rapid expansion of mining has brought a number of significant environmental and social problems relevant to planning in the Ayeyarwady Basin. Social issues include poor occupational health and safety at mine and mineral processing sites, public health issues related to high levels of drug use among miners, issues related to the appropriation or contamination of farmland by mining, and booming sector effects affecting food and basic commodity prices in areas around mining encampments. Environmental issues include: erosion, soil loss, and sediment generation; deforestation and biodiversity loss in areas around mine sites; water and land pollution issues from the use of mercury and cyanide, from mine tailings and mine drainage; and other localised pollution issues relating to air and noise pollution. These issues are compounded by the failure to effectively regulate the industry.

The development of the energy sector in the Ayeyarwady Basin is critical to support national development, especially in response to rising energy demands of a rapidly growing economy undergoing significant structural change. The development of the sector also has wide-ranging implications for the development of the basin. Overall energy demand is growing rapidly as the country develops. This is especially true of demand for modern, commercial energy such as refined oil products, gas, and electricity. Despite high demand growth, per capita consumption remains low by international standards, and the energy intensity of the economy remains high, reflecting widespread and inefficient energy use (largely related to the predominance of fuelwood use).

Biomass currently dominates energy consumption and production in the Ayeyarwady Basin, although its use is declining as electricity becomes more widely available. This has important implications for the Ayeyarwady Basin as fuelwood and charcoal use are likely important drivers of deforestation and forest depredation more generally. High levels of biomass use are largely due to household use of fuelwood and charcoal for water heating and cooking. The widespread use of such fuels in industry cannot be overlooked (artisanal oil refining, brick making and ceramic firing, lime production, etc.). In addition, the border trade in charcoal to meet demand due to silicone manufacture in Yunnan is also an important localized driver of charcoal demand. Aside from the implications for forest loss and degradation in the Ayeyarwady Basin, the widespread use of fuelwood has important public health implications and is related to high levels of indoor air pollution and respiratory complaints.

The Ayeyarwady Basin is home to a considerable amount of HP, with 14 large plants currently in operation (approximately 2.1 gigawatts [GW] of installed capacity), a further 3 under construction (1.37 GW) and 29 planned (25.6 GW). Most of these are planned for the mountainous Upper Ayeyarwady and Middle Ayeyarwady HEZ with fewer plants in the Chindwin and Lower Ayeyarwady. Most HP plants built to date have been funded by the public sector, built for both HP and irrigation purposes. These have relatively limited installed capacity and generally provide power for domestic consumption. However, beginning in the 2000s this changed as large dedicated HP plants were built more frequently, and were predominantly Chinese owned or often funded with a share of power production for export to the People's Republic of China. This trend is set to continue with mostly foreign owned and funded plants for HP production in the development pipeline.

While there is undoubtedly a pressing need for the electricity HP could offer, if all of these plants are built the impact on the basin could be substantial. Significant changes in flow regime and sediment load will alter many bio-physical processes in the basin. Many communities in upland areas will be displaced and natural systems (particularly aquatic systems) will be disrupted, affecting their diversity and productivity.

The Ayeyarwady Basin holds the vast majority of Myanmar's known onshore oil and gas reserves, mainly found around the Magway Region. The Ayeyarwady Basin also hosts Myanmar's three main oil refineries, and most of its domestic oil and gas pipelines. The basin is also cross cut by the Shwe oil and gas pipeline linking the Shwe gas field and the oil terminal at Kyaukphyu to Kunming in Yuanan, People's Republic of China. The onshore oil and gas sectors serve domestic demand and are in decline generally. There are remaining under-explored sedimentary basins in the west of the country, although it is unclear what potential these represent. There are also significant sub-bituminous coal reserves in the Ayeyarwady Basin, in the Chindwin River Basin; the reserves at Kalewa in particular are associated with a 600 megawatt mine-mouth power plant under construction, which in turn is linked to the development of copper mining and processing near Monywa. ASM and refining of oil and coal is also important in some areas of the basin.

The Ayeyarwady Basin also has significant renewables potential, with solar, small-micro-pico HP, biomass, and wind resources throughout the basin. Solar resources are particularly promising in the Central Dry Zone, biomass is promising in rice producing areas, and wind is promising in coastal and some upland areas. However, to date the sector has seen relatively little development. There is a vibrant community of domestic manufacturers of small HP and biomass gasifiers, which supply a significant portion of the off-grid Ayeyarwady Basin population with power through local mini-grids.

Power sector development in the Ayeyarwady Basin is a critical issue to meet growing power demand for domestic and industrial use. Myanmar has a very low level of per capita electricity consumption by international standards, reflected in the low level of electrification in rural areas and a general reliance on captive generation either as a primary supply source or as backup to a poor-quality supply. The lack of reliable power is a key concern for industry and a deterrent for investors, who face the alternative of installing expensive captive generation capacity. Overall, as is typical at Myanmar's stage of development, the sector has suffered a vicious cycle of financially unsustainable subsidies, resulting in a lack of investment, which in turn has forced the most valuable users to seek off-grid alternatives. This pattern started to change during the 2000s with the renewed and rapid development of the HP sector.

The key issue facing transport in the Ayeyarwady Basin is that there have been decades of underinvestment, which have affected all transport modes. As a consequence of this, there has been a degradation of pre-existing networks and a reduction in capacities and operating speeds to the point where railways are operating largely at capacity, road pavement conditions are often sub-optimal and Inland Water Transport (IWT) volumes have declined. There has been substantial growth in road freight transport in recent years in the Ayeyarwady Basin. However, capacity bottlenecks may yet arise, or in the case of Yangon, worsen. Rail freight northbound has also seen strong demand, but capacity constraints are already being felt.

The Ayeyarwady Basin includes 4,755 kilometres (km), or 70.5%, of navigable inland waterways in Myanmar, however the last few years have seen significant reductions in waterborne freight transport. The potential for water transport is currently constrained by a number of factors:

- A backlog of dredging works which have resulted in the upper reaches of the Ayeyarwady and Chindwin rivers being non-navigable in the dry season, and have restricted draft and increased sailing times in other sections of the rivers;
- A lack of properly maintained, modern navigation aids, which curtails the sailing day to approximately 10 hours; and
- Slow loading and unloading times due to poor facilities at berths. As a consequence, private operators often load and unload at informal anchoring points. Manual loading and unloading adds time and expense to shipping operations and informal anchoring may also have environmental consequences.

Other constraints that may impact the development of IWT in the future include:

- A lack of proper warehousing facilities;
- The shipping fleet's very old age, and hence likelihood to be quite inefficient and more environmentally damaging than newer, more efficient vessels;
- Containerisation, which could trigger the development of new industrial areas along the Ayeyarwady Basin; and
- Freight handling charges, including for containers, which are currently seen as prohibitively expensive by vessel operators (private and IWT alike).

The liberalisation of regulations on the import of second-hand vehicles into Myanmar has resulted in substantial growth in the vehicle fleet and hence additional competition to IWT methods. However, another change which would appear to have had a material impact upon IWT are policy reforms in the mining and forestry sector, which have led to significantly reduced demand for the transport of logs and mining materials. IWT has the potential to be more financially, economically, and environmentally efficient than other modes in the Ayeyarwady Basin. However, it should however be noted that full realization of such gains would require containerisation, whereas IWT in Myanmar is not generally containerised at present.

Manufacturing industry is in the relatively early stages of development in Myanmar and the Ayeyarwady Basin and began a period of rapid growth in the early 2000s. The Government of Myanmar is actively promoting the sector as it hopes to follow the path of export led, foreign invested manufacturing pursued successfully elsewhere in the region. This development is likely to be centred in the Ayeyarwady Basin, in particular in Yangon and Mandalay. The small and medium-sized enterprises in the food and beverage sector serving domestic markets have dominated manufacturing until recently. Recent growth has been concentrated in larger scale enterprises in garment and footwear sectors for export. Most foreign investment in the sector has focused on the garments and footwear sectors. Growth in the sector is likely to be diversified as the economy grows. Meeting domestic demand for basic goods is likely to be key, as is adding value to the basin's abundant natural resource output.

Development of the sector will pose challenges for basin management in terms of flood risk, water use, pollution, the development of ancillary infrastructure, and changing population dynamics. However, a proper evaluation of the sector in the Ayeyarwady Basin is stymied by a lack of information on the number, location, size, and type of manufacturing activity in the basin. Without this, it is not possible to identify likely impacts of sector development or their significance for sustainable development in the Ayeyarwady Basin. Therefore, the first step in addressing the sector needs to be the development of a comprehensive database of manufacturing industry in the basin.

Myanmar's rapid economic growth (Chapter 2) has led to significant declines in poverty and improvements in livelihoods (Chapter 4). Based upon the latest estimates, between 2004/2005 and 2009/2010, the poverty rate has declined from 44.5% to approximately 37.5%, and by 2015 it had declined further to an estimated 26.1% (MPF and World Bank, 2017). At the same time, all indications are that levels of inequality have risen. Inequality at the aggregate level is not where it presents a major issue, whereas inequality and distributional issues between different groups in the country and the basin are an important issue. These are not always manifest in terms of household income or employment, but relate to broader outcomes in health, employment, access to resources, and security. We examined access to land, gender, civil conflict, and peacebuilding as key cross-cutting distributional issues in the Ayeyarwady Basin.

Land is the single most important asset for most households in Myanmar. Moreover, as approximately 70% of the population are involved in agriculture and related activities, land also represents their main means of subsistence. The rapid economic changes Myanmar is currently undergoing are resulting in dramatic consequences to land access and tenure. With increasing investment, land in certain locations is increasing in value. This is particularly common in upland areas of the basin, which have seen extensive development of agro-forestry plantations (Chapter 7), mining (Chapter 8), oil and gas infrastructure (Chapter 9), and HP (Chapter 9).

Land disputes are increasingly common throughout the country and Ayeyarwady Basin. In the Ayeyarwady Basin, important land related issues include weak tenure arrangements for land in both urban and rural areas. Customary tenure arrangements face particular problems in upland areas. Issues relating to access to land and increasing landlessness are concentrated in lowland areas. Other issues include those related to displacement due to conflict and those associated with urban areas and rapid urban development.

The current land administration leaves much to be desired. Land policy reforms are being developed, however, issues relating to informal tenure, overlapping land use/tenure rights, historical land disputes, and outdated and incomplete cadastral records, not to mention the presence of semi-autonomous jurisdictions within the Ayeyarwady Basin, which grant alternative land tenure rights, remain. The weak tenure and land administration context is likely to be an important factor restricting the more rapid development of small-holder agriculture. Stronger tenure could act to unlock small-holder investment, by enabling the collateralisation and mortgaging of land, and providing adequate security to enable long-term investments in the improvement of agricultural assets.

Gender disparities remain an important source of inequality in Myanmar. While the country ranks 85th out of 187 countries in the 2014 Gender Equality Index, there remain important gender-based inequalities in legislation, access to economic opportunities, and political representation. The United Nations Population

Fund notes that action on gender equality is hindered by a lack of research and statistics on gender outcomes. This has also presented difficultly in developing the Ayeyarwady Basin analysis (United Nations Population Fund, 2017). Nevertheless, available information points to important gender disparities in terms of labour market access, employment, and wage levels. Employment in the garments industry, which employs approximately 90% women, is often poor quality with low wages, poor environmental health and working conditions, and limited job security. Gendered roles and a heavy work load for women in rural areas remains issues, as does differential access to education. Women also face difficulties in areas such as establishing property rights.

Available data however, presents only a partial picture. Measures to address persistent gender inequalities will require, in the first instance, a better understanding of the problem. This in turn implies the need for the collection of gender disaggregated data for key indicators in the Ayeyarwady Basin.

Civil conflict and peace building are unavoidable and defining issues in some areas of the Ayeyarwady Basin, with significant implications for patterns of economic and social development. The emergence of civil conflict predominantly between ethnic armed groups and the central government/military has a long history in Myanmar. Despite recent advances in building peace in the country and Ayeyarwady Basin through the 1990s and 2000s, recent years have witnessed an increase in violence, particularly in the north of the Ayeyarwady Basin in Kachin and Shan states. The activities of the military, ethnic armed groups, and various other stakeholders in these areas are closely connected to the management and utilization of the rich natural resources in these areas. The jade, timber, gemstones, gold, and narcotics border trade has provided income for groups involved in these conflicts, while at the same at the same time incentivized the desire to hold these valuable assets.

Overall, the basin can be broadly chracterised in terms of three general, spatially distinct patterns. Firstly, that of unsustainable recource use in the sparsely populated upland areas. This includes timber extraction, mining, hydropower development and the expansion of agricultural land (both by small-holders and larger agro-forestry concessions). Secondly, rapid urban expansion and the development of export led manufacturing industry concentrated around the main urban areas of Yangon, Mandalay and other urban centres to a lseer extent. Finally,the relative economic stagnation of the main agricultural areas in the central dry zone andlower reaches to the river basin.

1 INTRODUCTION

1.1 The Ayeyarwady Basin in the National Context

The Ayeyarwady Basin has historically been the economic centre of Myanmar. It is the largest and most economically significant river basin in Myanmar, comprising 61% of total national land area and 66% of the national population. The Ayeyarwady Basin covers an area of 413,710 square kilometres [km^2], of which 91% lies within Myanmar, approximately 5% (21,400 km^2) in China (mostly Yunnan), and 17,400 km^2 (4%) in India (Manipur and Nagaland). The Ayeyarwady is 2,170 km long, bisecting Myanmar from the Himalayas in the north to the Delta in the Andaman Sea. The N'mai and Mali rivers are the source of the Ayeyarwady, rising in the Himalayas, and joining at Myitsone, near Damphet in Kachin State. With total annual flow approximately 400 cubic kilometres (km^3), the Ayeyarwady ranks as the 22nd largest river in the world in terms of discharge. It is a monsoonal flood pulse river, with strongly seasonal flow, peaking during the wet season from July to September and reducing by an order of magnitude during the dry season.

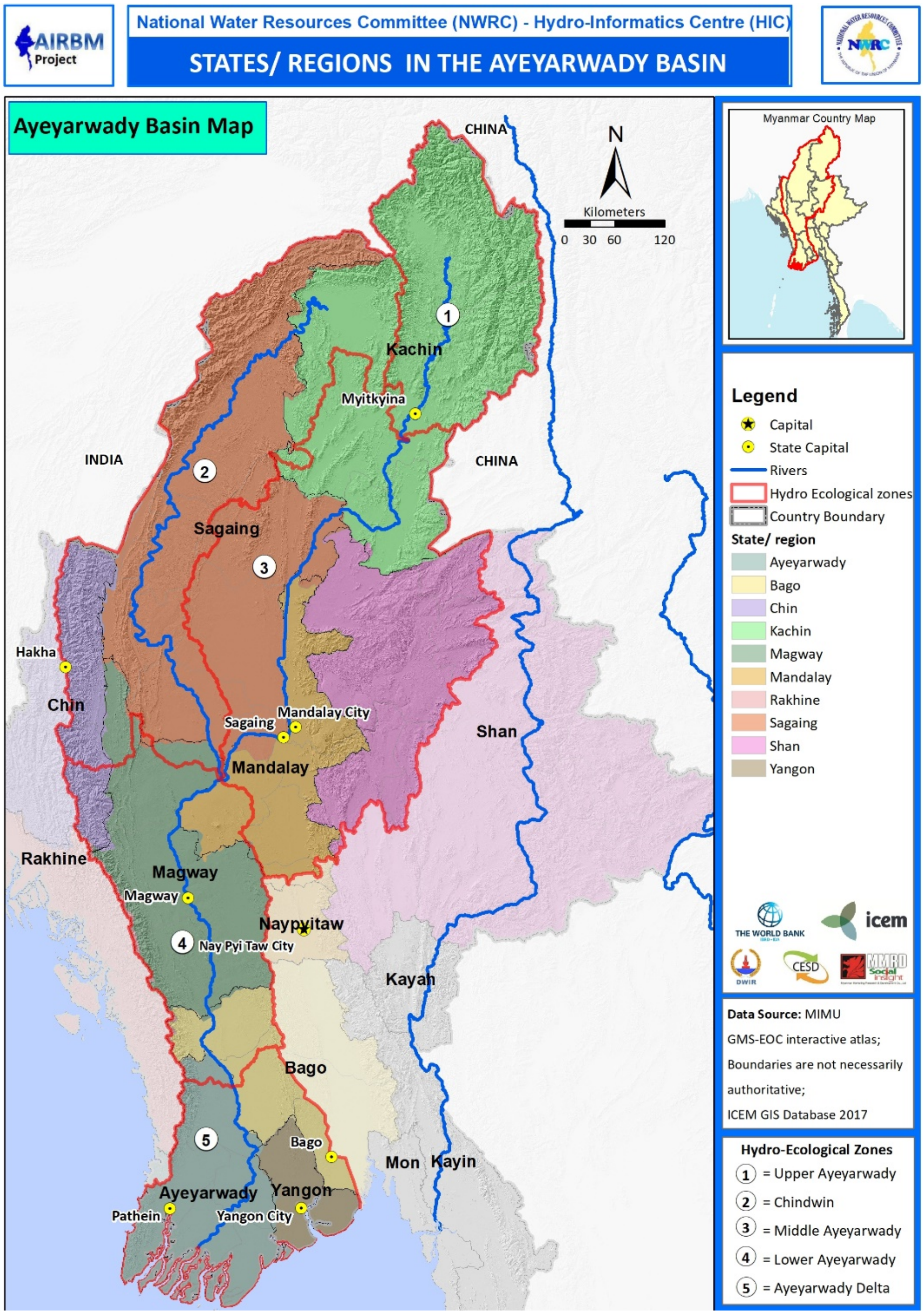


Figure 1 - The Ayeyarwady Basin, showing states and regions within the basin

The size of the Ayeyarwady River and the shallow longitudinal gradient mean that the river is navigable for much of its length opening up a vast highway deep into the dry zone and interior of the basin. The large alluvial floodplain in the dry zone together with the extensive deltaic system at the outlet have maintained a productive agricultural sector. Some 40 million peoples live in the basin including varied ethnic groups, many directly dependent on the Ayeyarwady's provisioning services of transport, food, and water placing the river at the centre of cultural and economic life.

Economic activity and population centres developed around irrigated rice agriculture in the central floodplains of the Ayeyarwady and the confluences of the Ayeyarwady with major tributaries such as the Myitinge, Mu, and Chindwin. As is still the case, the area was also the source of valuable timber, gemstones, and gold. Trade was generally overland with China to the north and India to the west. The location of the historical capitals of Mandalay and Ava in the Central Dry Zone (CDZ) are testament to the importance of this area.

The economic importance of Yangon and the lower reaches of the Ayeyarwady Basin including the delta only developed relatively recently. Lower Myanmar came to prominence with the development of global trade in the 15th and 16th centuries. The delta itself was not extensively drained and utilized for rice production until the 19th century. It was only really in the 19th and 20th centuries that economic activity moved decisively to Yangon. The movement of the capital to Naypyidaw in the northern Sittaung River Basin was therefore not without historical precedent.

Myanmar remains the least developed economy in Southeast Asia (UNDP, 2013). However, after decades of relative stagnation Myanmar is on the cusp of rapid economic and social transformation. With the elections of 2011, the country embarked upon a clear path of political reform that put an end to the country's relative political and economic isolation. The resumption of diplomatic and economic ties with the world has fuelled increasingly rapid economic growth in the country. Some projections foresee Myanmar's economy quadrupling in size over the next 15 years. Much of this growth will undoubtedly be in natural resource sectors - agriculture and fisheries, mining, and energy - which still dominate the country's economy. The manufacturing sector - also expected to be important in future economic development - will be dependent upon these natural resource sectors for inputs, such as water, energy, and material.

It is against this broader context of rapid development that the sustainable management of water and other natural resources is emerging as a critical issue for the economy and for livelihoods in Myanmar, and for the Ayeyarwady Basin in particular, where the most intensive economic activity is concentrated.

1.2 Ayeyarwady Integrated River Management Project and the State of the Basin Assessment

The Ayeyarwady Integrated River Basin Management (AIRBM) Project, supported through a World Bank credit, aims to help Myanmar develop the institutions and tools needed for informed decision making in the management of national water resources and to implement integrated river basin management of the Ayeyarwady. The Ayeyarwady State of the Basin Assessment (SOBA) is the major initial technical product of the AIRBM Project, which lays the foundation for integrated water resources management planning. The SOBA seeks to develop a detailed and up-to-date understanding of the basin context, leading to a river basin management plan to guide a more sensitive and sustainable approach to development in the basin.

The SOBA consists of six main contract packages (SOBA 1 - 6), each focussing on a particular aspect of the Ayeyarwady Basin system: SOBA 1: Hydrology looks at surface water flows and hydrology; State of the Basin 2: Groundwater Resources of the Ayeyarwady Basin establishes a Water Information System for Data Management within its study of groundwater resources; State of the Basin 3: Sediments and Geomorphology (SOBA 3); State of the Basin 4: Biodiversity and Fisheries; State of the Basin Assessment 5: Sectoral Development and Macroeconomics Assessment (SOBA 5); and State of the Basin 6: Participatory 3D Mapping and Local Consultations, and Communities Atlas has engaged in a substantial community consultations exercise.

1.3 SOBA 5 Scope and Objectives

In the SOBA 5 report, we gather together and synthesise available secondary data on a broad range of socioeconomic development issues throughout the basin, including the macro-economic and demographic context, livelihoods, agriculture and irrigation, forestry, mining, energy, transport, urban development and manufacturing, cross-cutting equity and distributional issues, and three in-depth case studies. The report broadly represents the current state of understanding of socioeconomic systems throughout the river basin.

1.4 Approach and Methodology

SOBA 5 has been designed and conducted predominantly as a desk-based study. It has drawn on a wide variety of secondary data and reports on the Ayeyarwady Basin and Myanmar more generally. This includes large scale survey-based datasets such as the 2014 population and housing census and the 2010 Agricultural Census, geospatial data including infrastructure, land use and land cover, government and other statistics, and academic and grey literature (government, donor and NGO reports, press reports, etc.). Where possible the team members have sought to meet with government counterparts and other stakeholders to acquire information and verify the team's understanding of patterns of development in the basin.

Geospatial analysis also played an important in determining conditions in the river basin, as datasets from the census in particular were available at township level enabling a more accurate understanding of how conditions vary throughout the basin (more detail is given on the geospatial approach taken to the analysis of the census data in Annex II). Similarly, datasets on land cover enabled an understanding of agricultural activities in the basin as well as forestry trends and mining trends.

Finally, in addition to the analysis of secondary data sources, where possible the team undertook more detailed consultative approaches. This was possible for the investigation of navigation, and for three case studies. These case studies were identified in consultation with the Project Management Unit (PMU) and developed detailed understanding of important development trends and issues in the Ayeyarwady Basin in 1) teak certification, 2) the demand side of sediment mining, and 3) the multiple use hydropower (HP) and irrigation project on the Mu River.

1.5 Caveats and Limitations

SOBA 5 faced a number of important limitations that are important to consider, many of which are related to data quality and availability. Firstly, a lack of up-to-date data for many sectors was limiting; for example, detailed agricultural data for the basin was available through the 2010 Agricultural Census, but subsequent data collection activities relating to agriculture have been more limited. Second, lack of spatially disaggregated data represented a particular constraint particularly as the Ayeyarwady Basin cross-cuts administrative boundaries which typically define the spatial unit for which official data is collected. This has been addressed in a number of different ways; in some instances data has been reported at state or region level for administrative regions which fall within the river basin, while in other cases the assumption has been made that for state or regions within the Ayeyarwady Basin, indicator values are evenly distributed within the administrative unit, allowing a rough calculation of approximate quantities or values attributable to the Ayeyarwady Basin. In the case of the census data, a more sophisticated approach has been adopted allowing the approximation of Ayeyarwady Basin indicator values at the township level (Annex II). Nevertheless, the lack of spatially disaggregate data represents an important constraint for the analysis. Finally, some data sources are of poor quality. Government data is particularly problematic for some sectors and issues. For example, mining and forestry data systematically underrepresent the extent of these industries through the exclusion of illegal or informal trade, which remains extremely important. Poverty data is unreliable; similarly, the census data on migration seems to have shortcomings.

Efforts have been made in the report to address these limitations through the use of other sources to corroborate or add caveats to official data sources. Qualitative sources of data are used to build a qualitative picture where Ayeyarwady Basin data is absent or insufficient. Finally, care has been taken to qualify the presentation and analysis of data with respect to its coverage, vintage, quality, and accuracy.

1.6 Report Structure

This report is structured based on major socioeconomic themes and sectors in the basin. The following section looks at the broad macro-economic context and seeks to understand the Ayeyarwady Basin's contribution to the broader economy, as well as examine the likely extent of trade and investment in the basin. Chapter 3 looks at the broader demographic context, with a particular emphasis on understanding population distribution growth and movement in the Ayeyarwady Basin. This is followed in Chapter 4 by an assessment of livelihoods across the Ayeyarwady Basin. Chapters 5, 6, and 7 look in greater detail at the important natural resource sectors of agriculture and irrigation, forestry, and mining, respectively. Chapters 8 and 9 look at the critical infrastructure sectors of energy and transport, respectively. These two chapters have a focus on HP and river navigation, respectively, due to the importance these sub-sectors have for river basin planning. Chapter 10 examines the structure and development of the urban and manufacturing sectors with an emphasis on understanding the urban system in the Ayeyarwady Basin and its relationship to development of manufacturing industry in particular, which is expected to be an important driver of economic growth in the future. Chapter 11 examines important cross-cutting equity and distributional issues for the Ayeyarwady Basin including a discussion of land tenure, gender, and conflict. Chapter 12 contains three short case studies conducted to investigate important development trends and patterns in the basin, including studies on the demand side of sediment mining, the teak certification system, and the Mu River multiple-use HP and irrigation project. Chapter 13 offers an overview and discussion of socioeconomic development trends by hydro-ecological zone (HEZ).

2 MACROECONOMICS

2.1 Introduction

This section firstly describes the general macroeconomic context in Myanmar, which to a large extent conditions and explicates development tends in the Ayeyarwady Basin. It then establishes the broader role the Ayeyarwady Basin plays in terms of the national economy. This includes not only the provision of the basin's abundant natural resources, but also increasingly the development of higher value-added export focused manufacturing industry and services sectors. This report first takes an overview of the national economy before attempting to estimate the contribution of the Ayeyarwady Basin to the economy. Section 3 looks at the size and importance of the Ayeyarwady Basin to trade and investment flows.

A major caveat to this analysis has been the lack of data. Sub-national output and value-added figures have not been available, either at the aggregate level or for particular sub-sectors. Therefore, estimation has been made based on proxy data such as population distribution and type (rural/urban), land use (in agriculture and forestry), and the distribution of productive resources (mines, industrial zones [IZ], etc.). While this approach leaves something to be desired, it is a first step in understanding the economic role and importance of the Ayeyarwady Basin and the productive systems it supports for the national economy as a whole.

2.2 Overview of Myanmar's Economy

Myanmar is entering a period of rapid and significant economic growth and structural change as it begins to develop an industrial, market-oriented economy. During the late 1990s and 2000s, Myanmar was the beneficiary of rapid growth in the broader region and the boom in demand for commodities as well as modest domestic reforms enabling some private sector development. This trend has continued into the 2010s.

More recently political and economic liberalisation has enabled increased trade and foreign investment (International Monetary Fund [IMF], 2015). Since the election of a new government in 2011, economic sanctions have been eased, the currency peg has been abandoned, and the country's first law on foreign investment has been drafted after many delays. The subsequent National League for Democracy (NLD) election victory in 2015 added momentum to the continuing programme of economic reform. This was accompanied by further relaxation of international sanctions, particularly by the United States of America (USA) allowing firms and individuals to invest in Myanmar. These changes have enabled a rapid expansion of Foreign Direct Investment (FDI), from just 24 foreign enterprises registered in 2010 - 2011, to 213 firms by 2015 - 2016 (Central Statistical Organization [CSO], 2016). By the end of 2016, Myanmar had 1,108 registered foreign enterprises (CSO, 2016). Currently, the government is actively promoting foreign investment into all major sectors of the economy. This is part of a more general programme including the divestment of state owned enterprises and the general liberalization of the economy.

Myanmar's Gross Domestic Product (GDP) in 2015 was approximately US$ 70.5 billion (2010 prices), up from approximately US$ 16 billion in 2000 (World Bank, 2017a). Between 2000 and 2010, average real economic growth ran at approximately 12% and between 2010 and 2015 ran at approximately 8% (Figure 2). This is reflected in the rapid growth in GDP per capita since the mid-1990s after a long period of stagnation. In 2015, per capita GDP stood at approximately US$ 1,310 in constant 2010 prices or adjusted for relative purchasing power at US$ 4,930 (constant 2011 US$).

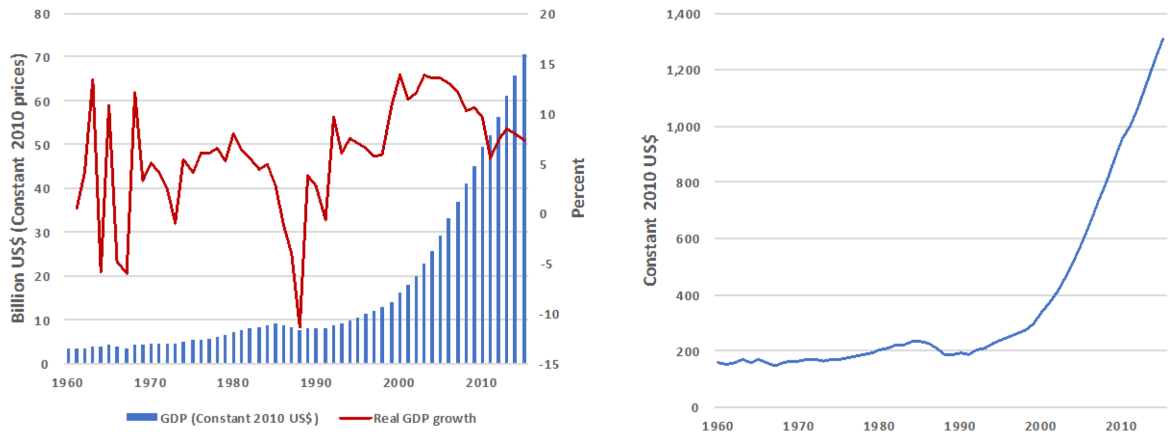


Figure 2 - National GDP and growth rate (a) and GDP per capita (b) 1960 - 2015

(World Bank 2017b)

Growth has been accompanied by rapid structural changes in the economy. As has been typical of many developing countries in the region, over the last 10 - 15 years, growth has been driven largely by the industrial and services sectors. Industrial and service sectors have seen growth rates of 21.4% and 12.5%, respectively, between 2000 - 2001 and 2014 - 2015. This contrasts with the agricultural sector, which has seen much lower levels of growth over the same period. Between 2000 - 2001 and 2010 - 2011 growth in the agricultural sector was approximately 9.6%, but since 2010 growth has stagnated. As a result, agriculture's share of GDP has steadily declined from approximately 57% of GDP in 2000 to approximately 27% of GDP by 2015, whereas the shares attributable to the industrial and service sectors have increased (Figure 3; Table 1).

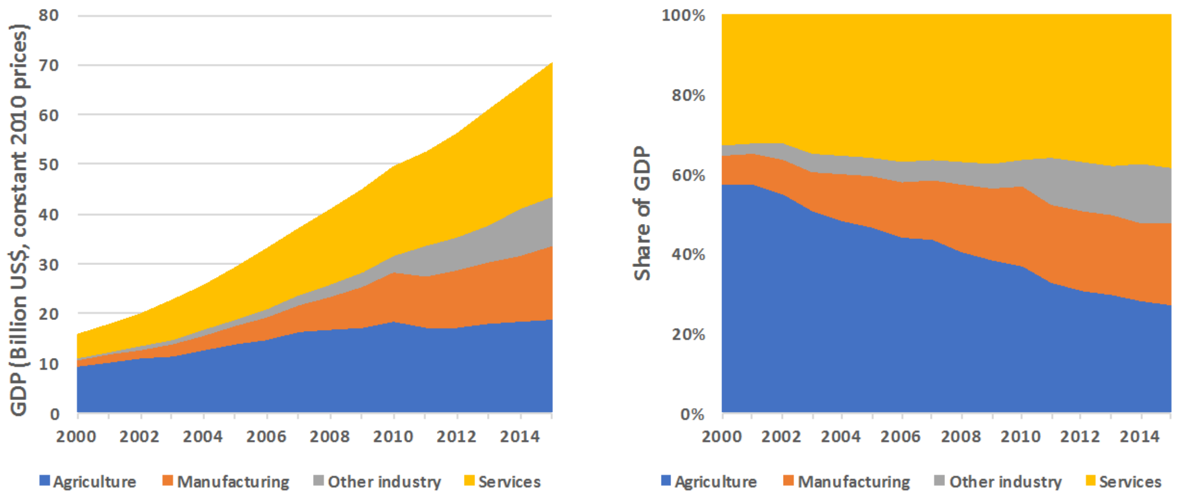


Figure 3 - GDP by major sector (a) and share of GDP by major sector (b) 2000 – 2015 *(World Bankm 2017b)*

Table 1 - Real value added by sector 2000/2001 to 2014/2015 *(CSO, 2016)*

Sectors	GDP (billion kyat, constant 2010 prices)							Average annual growth rate (AAGR) 2000/1 - 2014/5 (%)	Share of GDP 2015 (%)
	2000/ 2001	2005/ 2006	2010/ 2001	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015		
Agriculture	**5,884**	**10,974**	**14,659**	**13,649**	**13,790**	**14,436**	**14,761**	**6.3**	**27.9**
Agriculture	5,016	9,027	11,108	10,079	9,982	10,377	10,412	5.0	19.7
Livestock and fishery	811	1,800	3,392	3,409	3,642	3,903	4,237	11.7	8.0
Forestry	58	147	158	160	167	156	112	4.5	0.2
Industry	**996**	**4,116**	**10,528**	**13,143**	**14,594**	**15,818**	**18,232**	**21.4**	**34.4**
Energy	19	38	67	2,033	2,415	2,460	3,245	40.6	6.1
Mining	41	133	299	426	368	461	634	20.0	1.2
Processing and manufacturing	737	3,009	7,900	8,283	9,058	9,735	10,550	19.4	19.9
Electric power	14	53	422	437	541	586	748	30.5	1.4
Construction	185	883	1,839	1,964	2,213	2,576	3,055	20.5	5.8
Services	**3,400**	**8,415**	**14,590**	**15,209**	**16,696**	**18,626**	**19,934**	**12.5**	**37.7**
Transportation	589	2,455	4,594	4,999	5,376	5,836	6,073	16.8	11.5
Communications	28	247	332	365	533	770	988	26.7	1.9
Financial institutions	11	20	38	59	75	96	110	16.8	0.2
Social and administrative services	158	215	916	897	1,166	1,418	1,638	16.8	3.1
Rental and other services	141	376	738	801	964	1,115	1,243	15.6	2.3
Trade	2,471	5,103	7,971	8,089	8,583	9,389	9,882	9.7	18.7
Total GDP	**10,280**	**23,505**	**39,777**	**42,001**	**45,081**	**48,880**	**52,927**	**11.5**	**100.0**

At the same time, Myanmar remains a fragile state still emerging from over six decades of conflict and economic mismanagement. There remains a long way to go as state economic enterprises still dominate many traditional sectors of the economy, particularly in resource extraction and utilization. The economy is plagued by a weak and underdeveloped legislative framework, poor institutions, limited governance capacity at the central and sub-national level, and widespread corruption. The World Bank's flagship Doing Business 2017 report ranks the country at 170 out of 190 countries, which is the worst performance in the Association of South East Asian Nations (ASEAN), alongside countries such as Afghanistan and Iraq (World Bank, 2017a). Such regulatory and institutional weaknesses are critical particularly in the natural resources sectors.

2.2.1 *Agriculture and Forestry*

As noted above, Myanmar is experiencing a rapid decline in the relative importance of the agricultural sector as its growth is outstripped by that in the industrial and service sectors. Nevertheless, agriculture still accounts for approximately 27% of GDP, or approximately US$ 18.9 billion (2010 prices) in 2015. It also remains a strategically important sector providing approximately 16% of export earnings, supplying raw materials to the manufacturing sector, and accounting for more than 60% of employment. The sector is also critical for food security and poverty reduction. Performance in the sector is related closely to performance in the food-crop sector, which accounts for approximately 80% of agricultural production.

The sector has seen a significant slowdown in growth in recent years. After quite rapid growth of approximately 8.4% between 2000 and 2005, and approximately 6% between 2005 and 2010, growth has slowed dramatically since 2010 to an average of approximately 0.1% between 2010 and 2015. The slow-down in agricultural sector growth has been attributed to a sequence of extreme weather including cyclones and flooding, which have affected important agricultural areas. These started with Cyclone Nargis in 2008 which affected large parts of the Ayeyarwady Delta, followed by flooding in Rakhine State in June 2010 and Cyclone Giri in October 2010, flooding in Magway Region in 2011 and widespread flooding nationally in 2012 and 2015, all of which negatively impacted long-term agricultural productivity (International Programme on the Elimination of Child Labour, 2015; United Nations Institute for Training and Research, 2017).

Similarly, the forestry sub-sector has seen a declining share of GDP, and output from the sub-sector has declined in recent years. In 2014 - 2015 it was estimated to account for only approximately 0.2% of GDP (Table 1). Like agriculture, the sector remains important in the provision of subsistence goods to rural households, as a source of employment (employing 36,000 directly in 2011 and indirectly up to 500,000 [Woods and Canby, 2011]), as an important export sector (estimated at US$ 1.5 billion in 2013 [Woods, 2015]).[1] Unlike agriculture, the forestry sector seems to have limited upstream linkages to higher value-added production and most exports have been of raw timber.

2.2.2 *Industry and Manufacturing*

Industrial growth has been relatively high over the last 10 - 15 years (Table 2). The growth rates of mining (20%), energy (41%), manufacturing (19%), electric power (31%), and construction (21%) were all very high, which in some cases started from an initially low base. Primarily, this growth reflects the development of extractive sectors as a number of large projects have been developed in off-shore gas, HP, and mining, as well as the rapid expansion of small-scale mining in some areas. Much of the groundwork for the expansion of these extractive industries took place prior to the reform period, often in cooperation with Chinese investors. While manufacturing also grew at a rapid pace over the same period, the reform period has seen a more moderate growth trend. It is not clear if this was in response to the global economic environment, the restructuring and divestment of state-owned enterprises (SOEs), or other factors. However, renewed interest by foreign investors more or less since the beginning of the reform period coupled with the development of a more favourable policy environment for FDI, the development of large well services special economic zones (SEZs) and the availability of low-cost labour, mean that investment in manufacturing is growing rapidly (see Section 10 on manufacturing).

2.2.3 *Services*

The service sector has grown a little more quickly than GDP overall, increasing its share from approximately 30% in 2000 to approaching roughly 39% by 2015. The services sector is currently the single largest sector of the economy. The growth in the services sector reflects growth in the wider economy with increases in demand for transport, communications, trade and tourism, and building rental among other things. In 2014/2015 the largest services sub-sectors were trade and tourism (50%) and transport (31%). Trade and tourism have benefited in particular from the lifting of economic sanctions and greater focus on attracting FDI and export -led manufacturing development. Currently, the services sector is estimated to employ approximately 23% of the work force. As with the manufacturing industry, service sector growth has been concentrated in the large and growing urban centres such as Yangon and Mandalay.

2.3 Estimating the Contribution of the Ayeyarwady Basin

Sub-national value-added and output figures have not been available for the river basin or for states/regions of the Ayeyarwady Basin. In determining the role of the Ayeyarwady Basin in the broader national economy, estimates have therefore been based on proxy data. In this section, we look at the major sub-sectors in the Ayeyarwady Basin and attempt to ascertain their importance to the national economy.

[1] This estimate is based on records from importing countries, it is significantly higher than Government of Myanmar figures which put exports at US$ 914 million in 2013.

2.3.1 *Agriculture and Forestry*

In 2014/2015, crop production accounted for approximately 19.7% of national GDP, livestock and fisheries accounted for 8%, and forestry accounted for 0.2% (Table 2). Without access to data on crop production or cropping intensity for the Ayeyarwady Basin the estimate of the contribution of the Ayeyarwady Basin crop sector to national agricultural value added is calculated based on the share of agricultural land in the Ayeyarwady Basin. According to the 2010 Agricultural Census, there was approximately 12.7 million hectare (ha) of agricultural land nationally. Of this, approximately 7.5 million was within the Ayeyarwady Basin, equivalent to approximately 59% of agricultural land nationally. Assuming productivity is on average the same in the Ayeyarwady Basin and the rest of the country, and that change in productivity between 2010/2011 and 2014/2015 has been the same throughout the country, the value-added attributable to the Ayeyarwady Basin would be Myanmar kyat (MMK) 6,143 billion or approximately 11.6% of GDP.[2]

The attribution to national livestock and fisheries production in 2014/2015 was MMK 4,237 billion or approximately 8% of GDP. 2010/2011 figures from the Agricultural Census for livestock in the Ayeyarwady Basin are reported in Chapter 2 on agriculture (here in Table 2). To obtain the share of national livestock production, livestock figures were converted into commensurate livestock units (LSUs).[3] Based upon this conversion in 2010/2011, the total number of LSUs in the Ayeyarwady Basin was 8.3 million and nationally 21.7 million, suggesting the Ayeyarwady Basin accounts for approximately 38% of livestock nationally.[4]

Table 2 - Livestock production in the Ayeyarwady Basin and nationally 2010/2011 *(Agricultural Census, 2010; CSO, 2016)*

Animal	Animal number (million)		LSU (million)			Ayeyarwady Basin share (%)
	Ayeyarwady Basin	National	Conversion factor	Ayeyarwady Basin	National	
Cattle	6.7	13.6	1.0	6.7	13.6	49.3
Buffalos	0.7	3.0	1.0	0.7	3.0	24.9
Sheep/goats	0.9	4.1	0.1	0.1	0.4	21.7
Pigs	1.6	9.4	0.3	0.5	2.8	16.9
Poultry	19.7	156.4	0.0	0.2	1.6	12.6
Ducks	2.5	15.8	0.0	0.0	0.3	15.5
Total	-	-	-	**8.3**	**21.7**	**38.1**

Aquaculture production is more difficult to estimate; while figures for fish and shrimp production and the area of aquaculture ponds in the Ayeyarwady Basin are available, these do not seem to be consistent with national level figures. Nevertheless, the figures suggest that approximately 1.01 million tonnes (Mt) of fish and shrimp were produced nationally in 2015 - 2016. Assuming a similar rate of growth as that between 2010 and 2015, output would be expected to be 1.05 Mt in 2016 - 2017. Figures for 2016 - 2017 suggest that the Ayeyarwady Basin production stood at approximately 863,000 tonnes (t), or approximately 82% of national aquaculture production. In terms of total fisheries production, which is estimated to be approximately 5.92 Mt in 2016/2017, the Ayeyarwady Basin aquaculture share is approximately 15%. As with the other estimates, it is assumed that the Ayeyarwady Basin share has not changed between 2014/2015 and 2016/2017. Also it is important to note that capture fisheries, which may be significant, have not been taken into account in this estimate; this is likely to result in an underestimation of the Ayeyarwady Basin contribution to national fisheries production.

[2] This assumes that agricultural land throughout the country is equally productive. Given the large variation in agro-ecological characteristics and farming systems throughout the country this assumption only represents a first approximation. While the Ayeyarwady Basin itself has a large variation in farming systems, it also accounts for some of the most productive agricultural land.
[3] See Section 5 for a more detailed account of LSUs.
[4] It is assumed that all types of livestock in terms of LSUs are equally productive and that there is no significant variation in average livestock productivity between the Ayeyarwady Basin and Myanmar as a whole. It is also assumed that productivity or the relative share of livestock production has not changed between 2010/2011 and 2014/2015.

The next difficulty is that there is no clear indication of the share of livestock and fisheries output accounted for by aquaculture output, and that accounted for by agricultural output. As noted elsewhere, fisheries production in Myanmar is at lower levels than those in other Southeast Asian countries. We assume that aquaculture production in Myanmar accounts for 30% of the value-added of livestock and aquaculture production combined. Based upon these assumptions summarized in Table 3, we estimate that livestock and aquaculture production in the Ayeyarwady Basin was equivalent to approximately 3.1% of GDP in 2014/2015 or MMK 191 billion. These figures do not include capture fisheries for which estimates were not available.

Table 3 - Estimating the Ayeyarwady Basin share of value-added attributable to livestock and fisheries production 2014/2015

	Value (billion kyat, constant 2010 prices)	Estimated share of GDP in 2014/2015
National		
Livestock and fisheries	4,237	8%
Livestock	2,966 (~70% of livestock and fisheries)[1]	5.6%
Fisheries	1,271 (~30% of livestock and fisheries)[1]	2.4%
Ayeyarwady Basin		
Livestock and fisheries		2.5%
Livestock	1,127 (~38% of national)[2]	2.1%
Aquaculture	191 (~15% of national)[3]	0.4%

[1]*Based upon an assumption that livestock and fisheries value added is split 70%, 30% respectively.*
[2]*Based upon census estimates on the number of livestock in the Ayeyarwady Basin and national figures from CSO.*
[3]*Based upon figures for aquaculture production of fish and shrimp from township fisheries statistics and national figures from CSO.*

The forestry sector accounted for only approximately 0.2% of GDP or MMK 112 billion in 2014/2015 according to CSO figures. To estimate the share of the Ayeyarwady Basin in this statistic, we assumed that hardwood timber production accounted for 90% of this figure, with the rest comprised of other types of timber and fuelwood. It was assumed that most fuelwood and non-timber forest products (NTFPs) were used on a non-commercial basis or were not reported and therefore not included in the GDP figures. Figures on hardwood production (teak and other hardwoods) was obtained from the CSO yearbook for Ayeyarwady Basin states and regions. It was assumed that value-added was directly proportional to the volume of hardwood production. These figures are reported below (Table 4). They show that the Ayeyarwady Basin states/regions accounted for approximately 87% of hardwood production, and based on this an estimated MMK 88 billion in value-added, or 0.16% of GDP.

Table 4 - Ayeyarwady Basin share of hardwood production and forestry GDP *(CSO, 2016)*

State/region	Hardwood production (m^3)	Share (%)	Value-added (billion MMK, constant 2010 prices)
Kachin State	22,632	2.7	2.7
Chin State	9,505	1.1	1.1
Sagaing Region	326,891	38.9	39.2
Bago Region	105,004	12.5	12.6
Magway Region	26,810	3.2	3.2
Mandalay Region	170,255	20.3	20.4
Shan State	59,779	7.1	7.2
Ayeyarwady Region	13,489	1.6	1.6
Ayeyarwady Basin total	734,365	87.4	88.1
National total	840,399	100.0	100.8

Based upon these estimates approximately 14.26% of GDP was attributable to the Ayeyarwady Basin agricultural sector in 2014/2015.

2.3.2 *Industry and Manufacturing*

As with agricultural production, there was neither available sub-national data for estimates of value-added, nor consistent proxy data upon which to base estimates of industrial production. Rather, it is a case of piecing together ball-park estimates from fragmentary and partial evidence. To do this we look at each sub-sector in turn, and consider what the evidence available can tell us.

The energy sector is important in some areas of the Ayeyarwady Basin. The sector includes commercial energy sources excluding electrical power generation and coal mining, but includes other commercial energy production, refining, storage and pipeline transport. National energy production is focused off-shore, however, practically all onshore production is within the Ayeyarwady Basin, as is all refining capacity and most of the domestic pipeline network.[5]

Table 5 gives the share of national oil and gas production estimated to take place in the Ayeyarwady Basin. This does not include artisanal and small-scale mining (ASM) oil extraction activities. These are used as a proxy for estimating the share of GDP accruing to the energy sector. It is assumed that productivity across the sector is the same for oil and gas and that share of value added is the same as the share of revenues. Using Myanmar Oil and Gas Enterprise (MOGE) figures on the value of gas and oil production in 2013/2014 and production share as calculated in Table 5, the share of national oil and gas revenues attributable to activities in the basin is estimated to be 11.1% (Extractive Industries Transparency Initiative [EITI], 2015), equivalent to approximately MMK 360 billion in 2014/2015.

Table 5 - National and Ayeyarwady Basin oil and gas production 2013/2014 *(EIS and Myanmar International Consulants [MMIC], 2015)*

	National	Ayeyarwady Basin	Ayeyarwady Basin share of national (%)
Oil	20,000 barrels per day (barrels day^{-1})	8,000 bbl day^{-1}	40
Natural Gas	20 billion m^3	1.5 billion m^3	7.5

Estimating the value of mining in the basin is especially problematic. The industry is extremely heterogeneous. Moreover, mining that is not conducted as part of a joint venture (JV) with a state mining enterprise is effectively unmonitored (Irwin, 2016). It is not entirely clear what the basis of the national GDP figures are against these considerations.[6]

Output value of the three mining SOEs was reported to be MMK 254,675 million and that of jade and gem sales MMK 1,471,130 million. This excludes undeclared production, which is thought to be significant (Section 1.3.3 below). It is assumed that other mining activity takes place in the same proportion as state operated activities. Firstly, all gem and jade production is from the Ayeyarwady Basin, already of the MMK 1,725,805 million, roughly 85% is attributable to gem and jade production coming from the Ayeyarwady Basin.

We have various proxies of the remaining 15% of mining revenue. The share of mines in Ayeyarwady Basin states/regions is 87%, the share of employment is approximately 92%, and the share of mining areas detectable by GIS is 87 - 88% (see Section 7). Based upon this we assume that mining in the Ayeyarwady Basin accounts for approximately 90% of the remaining mining activity in the country, or 13.5% of other mining activity nationally. Therefore, assuming that GDP is attributable in a similar way, the basin accounts for 98.5% of national mining value added, or MMK 625 billion.

Manufacturing contributes a much more significant share of GDP at MMK 10,550 billion or 19.9% in 2014/2015. However, no spatially disaggregated data relating to output or productivity has been available. Available

[5] International pipelines may also be important, although it is not clear how revenues accruing to such a network are attributed.
[6] Even leaving aside considerations of unreported and smuggled production.

data on the size and distribution of manufacturing activity has been limited to enterprise registration, some investment data by region/state, and information on investment and employment by IZs in the Ayeyarwady Basin. As these do not represent consistent proxies, the proportion of urban population has been used as an alternative. Manufacturing tends to be concentrated in urban areas, often in the urban periphery. Urban population figures from the 2014 census (UNFPA 2014) show the share of urban population within the Ayeyarwady Basin (Table 6).

Table 6 - Urban population share and estimated share of manufacturing value added 2014/2015

State/region	Urban population (1,000)	Share of national (%)	Estimated manufacturing value-added (MMK billion)
Ayeyarwady	814	5.5	578
Bago (West)	376	2.5	267
Chin	72	0.5	51
Kachin	592	4.0	420
Magway	588	4.0	417
Mandalay	2,143	14.4	1,521
Sagaing	911	6.1	647
Shan (North)	333	2.2	237
Shan (South)	76	0.5	54
Yangon	4,920	33.1	3,492
Grand Total	10,826	72.8	7,684
National	14,864	100	10,550

Electrical power generation is easier to estimate. Total national installed capacity in 2014 was approximately 4,027 megawatts (MW) (Deloitte, 2015). Seventy-one percent of installed capacity is located in the basin, 65% of national HP capacity and approximately 90% of national gas capacity. There are numerous small HP plants and small generators throughout the basin and it is assumed that these are largely unincorporated into national statistics or that their generation output is not significant enough to change outcome of the estimation exercise. Generation from HP plants in the basin is estimated to be approximately 69% of total HP generation, or approximately 50% of national power generation. It is assumed that gas plants are operated at a similar capacity factor nationally, meaning the share of gas in national power generation is 23% and that of gas in the basin approximately 21% of national generation. While transmission and distribution (T&D) services also attract value added, it is assumed that these services are distributed roughly in line with generation.

As with manufacturing figures, no consistent disaggregated figures are available for construction activity. It is certainly the case that large construction projects are underway in the basin with little connection to urban development, such as the development of national highways, mine, and HP development. However, as with manufacturing, construction activity is deemed to be overwhelmingly associated with urban areas. Therefore, urban population is used as a proxy for the likely share of construction activity in the basin as with manufacturing production.

2.3.3 Services

Details of service sector activity is also limited. Without a geographical breakdown of service sector activity, again we have used the share of urban population as a proxy. As established above, the Ayeyarwady Basin urban population is approximately 72.8% of the national population; therefore, the value-added attributable to the Ayeyarwady Basin service sector is estimated to be MMK 14,512 billion.

2.3.4 *Summary*

Table 7 summarizes these estimates. As the Ayeyarwady Basin holds the two largest urban areas in the country (Yangon and Mandalay), and accounts for the lion's share of agricultural land, mining production, and power generation, the basin accounts for most of national GDP.

Table 7 - National GDP and estimated Ayeyarwady Basin contribution at 2014/2015 Consultants' estimates based on various sources (*constant 2010 prices*)

Sector/sub-sector	National		Estimated Ayeyarwady Basin		
	Value (MMK, billion)	Share (%)	Value (MMK, billion)	Share of Ayeyarwady Basin (%)	Share of national (%)
Agriculture	**14,761**	**27.9**	**7,549**	**22.5**	**51.1**
Agriculture	10,412	19.7	6,143	18.3	59.0
Livestock and fishery	4,237	8.0	1,318	3.9	31.1
Forestry	112	0.2	88	0.3	78.7
Industry	**18,232**	**34.4**	**11,420**	**34.1**	**62.6**
Energy	3,245	6.1	360	1.1	11.1
Mining	634	1.2	624	1.9	98.5
Processing and manufacturing	10,550	19.9	7,680	22.9	72.8
Electric power	748	1.4	531	1.6	71.0
Construction	3,055	5.8	2,224	6.6	72.8
Services	**19,934**	**37.7**	**14,512**	**43.3**	**72.8**
Transportation	6,073	11.5	-	-	-
Communications	988	1.9	-	-	-
Financial Institutions	110	0.2	-	-	-
Social and administrative services	1,638	3.1	-	-	-
Rental and other services	1,243	2.3	-	-	-
Trade	9,882	18.7	-	-	-
Total GDP	**52,927**	**100**	**33,481**	**100**	**63.3**

2.4 Ayeyarwady Basin Role in Trade and Investment

2.4.1 *Ayeyarwady Basin contribution to exports*

As noted above the Ayeyarwady Basin accounts for the lion's share of economic production in Myanmar. This is also reflected in the Ayeyarwady Basin's contribution to exports. As geographically disaggregated figures for export production have not been available, estimates have been based on the broader production estimate approach for different sub-sectors. Details of the estimation approach have been included in Table 11, Annex I. The export production figures for the basin are summarised in Figure 4. Overall, the Ayeyarwady Basin accounted for US$ 6.3 billion in 2014, approximately 50% of total exports. If gas exports are excluded, none of which are attributable to the Ayeyarwady Basin, then the Ayeyarwady Basin accounts for approximately 72% of exports. The importance of the Ayeyarwady Basin in the production of exports is generally due to the concentration of manufacturing in the basin and the importance of the mining industry, particularly as regards jade and gems. This figure would be substantially larger if the illegal trade in jade, gems, and timber were included in these figures (Section 2.4.3).

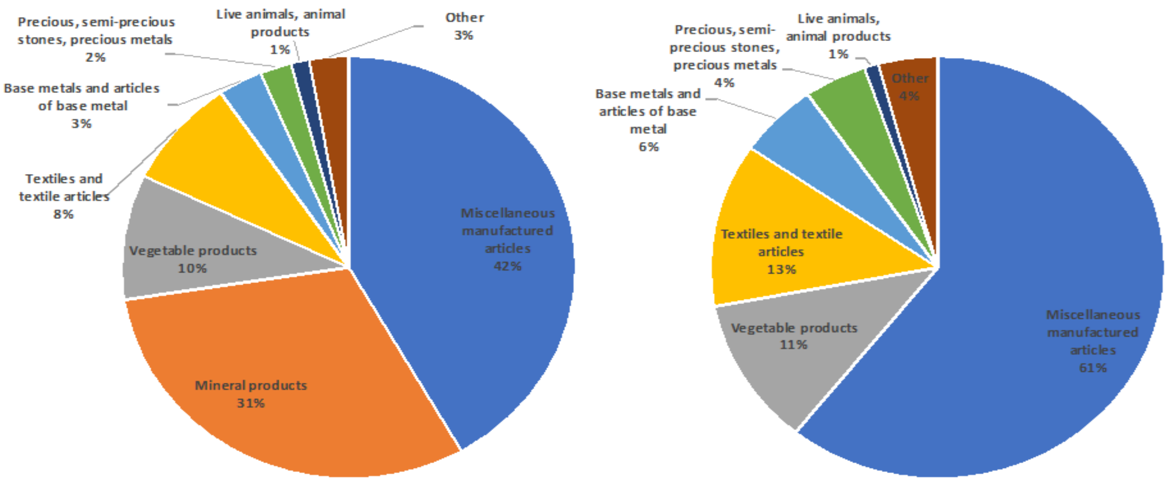


Figure 4 - Share of national (a) and Ayeyarwady Basin (b) exports in comparison 2014 *(CSO data and consultant's estimates)*

2.4.2 *Illegal trade*

When considering both macroeconomic figures and figures on exports it is important to bear in mind the extent of illegal trade, which while excluded from these figures, is likely to be particularly important for the Ayeyarwady Basin. As noted in the sections on energy, forestry and mining, the extent of illegal trade is likely to be large. Here we attempt to put it in its broader context, by considering illegal trade in jade and rubies, timber, and narcotics.

a) Jade and rubies

Export figures for 2014 estimate exports of jade and gems (and precious metals, jewellery, etc.) at a total US$ 280.47 million. This contrasts with the value of jade and gem exports given by MGE over the same period, which is US$ 1,444.17 million and US$ 6.56 million, respectively (EITI, 2015).[7] As EITI points out, this suggests that most gem and jade exports remain unrecorded. In addition, as noted in Section 7 on mining, estimates suggest 20 - 40% of jade and gem production is registered. Chinese import records over the same period recorded jade imports worth US$ 12.3 billion, 88% higher than MGE figures (Global Witness, 2015). In addition, reports suggest that smuggling into China is common, with only 20 - 50% of imports officially recorded. Based upon these considerations, Global Witness estimated that the actual value of jade exports to China could be in the region of US$ 30 billion. While this estimate may seem high, the overall message is that jade exports are considerably more significant than official figures suggest and are, in all likelihood, the largest export by value from Myanmar. All jade exports originate from the Ayeyarwady Basin.

Similar efforts have not been made for rubies, for which production is also under-reported and is subject to widespread smuggling (Irwin, 2015). As with jade it is estimated that only 20 - 40% of production is registered. This would suggest that estimates of ruby production and export should be 60 - 80% higher in 2014 than the US$ 6.56 million figure, and therefore in the region of US$ 10.5 - 11.8 million. As the figures for jade suggest, this too may be a significant underestimate. The vast majority of ruby exports come from Mogok in the Ayeyarwady Basin.

b) Timber

Figures for timber export are also problematic. Timber and related exports for 2014 were US$ 88.16 million, a significant reduction from the 2013 figure of US$ 914.18 million due to the introduction of the ban on raw timber exports. However, figures based on reported timber imports in China (mainly in Yunnan Province)

[7] Similar research conducted in 2011 found that Gems Emporium sales of US$ 2.65 billion were around 77 times larger than reported exports of US$ 34 million.

suggest an import value of US$ 1.75 billion in 2013, a figure 90% higher than reported exports (Woods, 2015). These figures also do not account for smuggled timber and it is not clear how significant this is. It is assumed that most of this illegally exported timber travel overland to China from the Ayeyarwady Basin, given than most remaining forestry production is concentrated in Sagaing regionand Kachin state.

c) Narcotics - opium and methamphetamine

Recent United Nations Office for Drugs and Crime (UNODC) reports identify Myanmar as an important source of narcotics production. Recent reports suggest that the trade in illegal narcotics in Myanmar is worth US$ 2 billion annually (New York Times 2015), both in terms of plant derived narcotics, and in particular opium and synthetically produced narcotics such as methamphetamine. Other narcotics are important but here we consider only opium and methamphetamine.

Myanmar is the largest producer of opium in Southeast Asia and the second largest producer in the world after Afghanistan. Most production takes place in Shan State and outside the Ayeyarwady Basin. In terms of the Ayeyarwady Basin, opium producing areas include Northern Shan State, Southern Shan State, Kachin State and Chin State (UNODC, 2015). Although production has declined significantly from the 1990s, since 2006 it has been on the rise again. In 2014, estimates suggest that in Shan State there were 51,400 ha of opium poppy cultivation, with an estimated dry opium yield of 480 - 920 t. With a farm-gate price of US$ 414 per kilogram (kg), the estimated value of the crop was US$ 240 - 470 million (UNODC, 2015). Assuming that this was all exported, this would have accounted for between 1.9 - 3.6% of total exports. It is not clear what the Ayeyarwady Basin share of opium production is likely to be. If we assume a conservative estimate of one third of national production, this would still amount to between 1.3 - 2.4% of exports from the Ayeyarwady Basin.

The trade and production of methamphetamine both in tablet and crystalline form is also becoming increasingly common in Myanmar. Methamphetamine in both tablet and crystalline form originating from Myanmar continue to be seized in neighbouring countries. Again, much of this production is situated in Shan State, and most of this is supplied to other Southeast Asian markets and China (UNODC, 2017). Table 8 shows the increase in seizures of methamphetamine from 2011 to 2015, showing a clear increase over the period; however, seizures are not a good guide to production and the figures included here are skewed by a large seizure in 2015. The number of users seeking treatment has also increased over recent years (UNODC, 2017). Estimates for the value of this illicit trade are not available, however, based on 2015 seizures alone, the methamphetamine tablet seizures were worth between US$ 150 - 300 million and crystalline methamphetamine US$ 4.5 - 22.6 million (UNODC, 2017). It is not clear what proportion of this trade is based in the Ayeyarwady Basin, but it is likely to be significant.

Table 8 - Methamphetamine seizures in Myanmar 2011 – 2015 *(UNODC, 2017)*

Drug Type	Measurement	2011	2012	2013	2014	2015
Methamphetamine tablets	tablets	5,894,188	18,162,052	10,187,014	12,650,000	49,950,000
Crystalline methamphetamine	kg	33.4	426.7b	173	47.1	2,261.90
Methamphetamine powder	kg	20.2	7.3	7.3	108.4	197.9

2.4.3 Ayeyarwady Basin investment

Inward investment is essential to ensure continued increased productivity and economic growth. This section gives a brief overview on available data on patterns of investment in Myanmar and the Ayeyarwady Basin.

a) Domestic investment

The limited data available on domestic investment is presented inTable 9. Reported domestic investment seems relatively modest. Amounting to US$ 2 billion over the three years reported, this contrasts with FDI of approximately US$ 226 billion over the same period. There is no indication as to the type of investment being undertaken. The figures are dominated by Mandalay and Yangon, suggesting most of the investment has been in urban business enterprises such as small-scale manufacturing and service sector investments. In terms of domestic investment, given the share of population and economic activity the Ayeyarwady Basin represents, it seems under-represented. This may be an indication that domestic private sector investors are being crowded out by foreign investment and state investment in the Ayeyarwady Basin, or simply that there is a lower propensity to report investment in the Ayeyarwady Basin area, and actual investment figures are higher than those here suggest.

Table 9 - Domestic private sector investment 2010/2011 - 2012/2013 *(CSO, 2016)*

State/region	2010 - 2011		2011 - 2012		2012 - 2013		Cumulative	Share of cumulative (%)
	No.	US$ (million)	No.	US$ (million)	No.	US$ (million)		
Kachin	2.0	144.9	-	-	2.0	5.2	150.1	7.4
Chin	-	-	-	-	-	-	-	-
Sagaing	1.0	-	1.0	-	4.0	9.4	9.4	0.5
Bago	4.0	117.7		-	1.0	9.9	127.6	6.3
Magway	1.0	4.7	1.0	0.3	1.0	4.7	9.6	0.5
Mandalay	10.0	91.8	7.0	138.8	9.0	168.1	398.7	19.6
Yangon	26.0	143.0	20.0	61.1	41.0	91.3	295.4	14.6
Shan	4.0	44.8	3.0	20.9	2.0	5.8	71.5	3.5
Ayeyarwady	4.0	0.1	1.0		2.0	0.3	0.4	0.0
Total Ayeyarwady Basin	**52.0**	**547.0**	**33.0**	**221.0**	**62.0**	**294.7**	**1,062.7**	**52.4**
Other	11.0	461.0	1.0	58.1	3.0	447.9	967.0	47.6
National	**63.0**	**1,008.0**	**34.0**	**279.1**	**65.0**	**742.5**	**2,029.7**	**100.0**

b) FDI

FDI has played an important role in the recent industrialization of a number of countries in east and Southeast Asia. The value of foreign investment lies not only in the quantity of capital foreign investors are able to raise, but also in the transmission of new technologies, techniques, skills, and training to the domestic workforce. The potential spill-over effects are thus thought to raise productivity in the economy and enable the broader development of higher-value added industries. However, in this regard not all FDI are equal, as some have a much greater potential for positive spill-over effects. For example, manufacturing industries employing local populations are likely to have greater spill-overs in terms of employment, skills, and training for a large number of people than investment in a power plant employing a few expatriate staff.

Table 10 gives detailed information on FDI commitments between 2010/2011 and 2015/2016 by state and region. Firstly, excluding large-scale HP investments in Kachin State in 2010/2011 and 2011/2012, figures show an increasing trend. Secondly, Kachin state and Sagaing region have attracted a substantial share of FDI for big-ticket natural resource projects such as mines and HP development. Yangon region, and to a lesser extent Mandalay region and Bago region, have seen a greater number of smaller projects. These are likely to be smaller scale investment in the manufacturing and service sectors. Third, there has been a dramatic increase in both the number of projects and overall investment in Yangon in particular; the developing concentration of these investment in Yangon is only likely to increase as the large SEZ there is further developed.

Table 10 - FDI in Ayeyarwady Basin states/regions and the rest of Myanmar 2010/2011 - 2015/2016 *(CSO, 2016)*

	2010 - 2011		2011 - 2012		2012 - 2013		2013 - 2014		2014 - 2015		2015 - 2016	
	No.	US$ (mil.)	No.	US$ (mil.)	No.	US$ (mil.)	No.	US$ (mil.)	No.	US$ (mil.)	No.	US$ (mil.)
Kachin	2	8,219	1	4,344	-	-	-	-	-	-	-	-
Chin	-	-	1	2	-	-	-	-	-	-	-	-
Sagaing	3	1,396	-	-	-	-	4	201	4	144	-	5
Bago	1	2	1	26	5	58	7	627	17	460	11	67
Magway	-	-	2	123	2	39	-	-	3	234	1	6
Mandalay	-	-	1	26	2	66	2	82	7	667	12	474
Yangon	3	64	5	33	80	834	102	2,745	154	3,767	159	3,863
Shan	-	-	-	-	1	199	2	33	1	17	3	154
Ayeyarwady	-	-	1	73	1	20	3	12	6	166	7	42
Other	15	10,318	1	18	3	206	3	407	19	2,556	20	4,871
Total	**24**	**19,999**	**13**	**4,645**	**94**	**1,420**	**123**	**4,107**	**211**	**8,011**	**213**	**9,481**

The Ayeyarwady Basin is currently the destination of most FDI to Myanmar, although at approximately 62%, this is less than may be expected given its share of economic activity (Figure 5). This may be a result of large natural resource investments outside the basin, such as the Shwe gas field and pipeline.

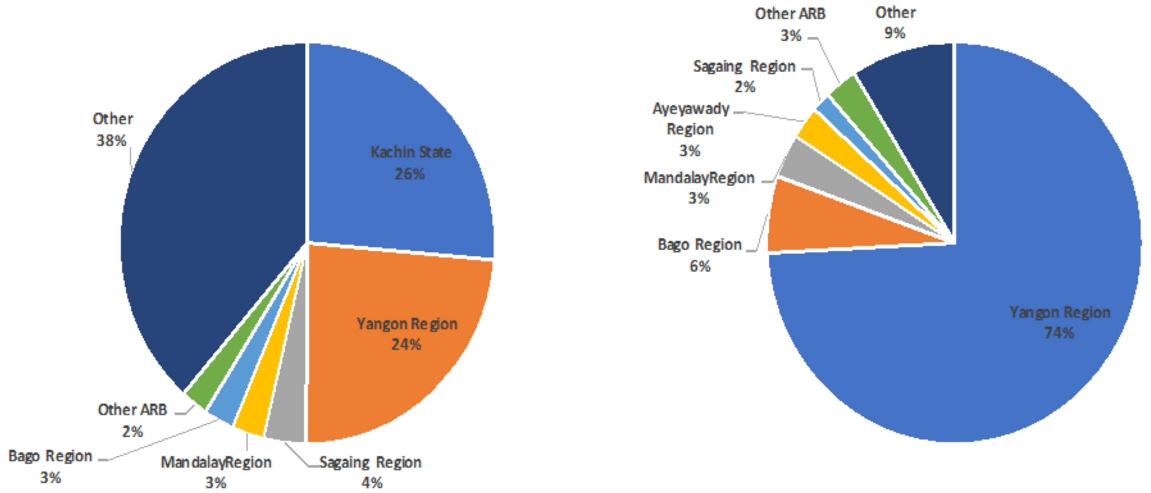


Figure 5 - Ayeyarwady Basin and national FDI by region/state, percent cumulative 2010/2011 - 2014/2015 investment value (a) and number of projects (b) *(CSO, 2016)*

While FDI in manufacturing is starting to take off, to date most FDI has been in the natural resource sectors. This may not be problematic in itself, however, such projects offer relatively little opportunity for positive spill-overs to develop, and therefore are unlikely to provide the broader productivity benefits usually associated with FDI.

2.5 Conclusion

Myanmar is entering a period of rapid economic growth and transition, and the Ayeyarwady Basin has been central to this change. The preponderance of natural resources in the Ayeyarwady Basin means it dominates agricultural and forestry production. Onshore energy production is also an important contributor to national and Ayeyarwady Basin value-added. The mineral resources concentrated in the basin, especially jade, gemstones, gold, copper, and nickel also mean the mining sector is an important source of economic production in the basin. The development of the power sector has also been concentrated in the Ayeyarwady Basin, with almost all gas turbines situated in the basin and large HP plants in particular in the

Middle Ayeyarwady HEZ. The presence of the country's largest urban areas in the Ayeyarwady Basin also mean that productive activities concentrated in and around urban areas such as manufacturing, construction and service sector activities contribute an important share of Ayeyarwady Basin value added.

If anything, excluding oil and gas exports, the contribution of the Ayeyarwady Basin to exports is even more significant due to the concentration of manufacturing in the basin and the importance of the mining industry, in particular the mining of jade and gems. If illegal exports of timber, jade and gems, and opium were included this may increase Ayeyarwady Basin export values by anywhere between US$ 13.2 - 31 billion in 2013/2014, or from more than 100% to almost 500%. Illegal trade flows are clearly important.

Investment is also concentrated in the Ayeyarwady Basin. Domestic investment in the Ayeyarwady Basin only totalled US$ 1.06 billion from 2010/2011 to 2013/2014. This is only 52% of domestic investment nationally, which means that the Ayeyarwady Basin sees a lower share of domestic investment than expected. However, this is dwarfed by FDI in the Ayeyarwady Basin, which accounted for approximately 62% of national FDI between 2010/2011 and 2014/2015, or a cumulative total of US$ 29.3 billion. Big-ticket infrastructure projects and natural resource related investments have been an important part of this. However, there is a trend for smaller urban based investments in the manufacturing and services sector.

The trends in economic production, exports, and investment in the basin all suggest that Myanmar is entering a period of rapid economic growth and structural change. Thus far the drive to promote investment in the manufacturing industry for export seems to be bearing fruit. This will be encouraged by the continuing development of critical infrastructure (in the transport and power sectors) as well as the development of SEZs, particularly those in Yangon which already seems to be an important draw for foreign investment. At the same time, investment is still concentrated in natural resource and extractive industries, many of which have limited potential for positive spill-overs.

3 DEMOGRAPHY

3.1 Introduction

The demographic analysis is not a sector analysis as it covers a wide set of subject matters that cross sectors. The focus is on the demography, i.e., a population profile including the normal variables of population size, sex-ration, population growth rates and population density, intra-basin migration, and emigration.

The objective of the analyses is to take stock of the status and trends of the key demographic characteristics and the socioeconomic and development situation of the communities living within the Ayeyarwady Basin, and to analyse the trends to assess their implications for the Ayeyarwady system. The geographical scope is the Ayeyarwady Basin disaggregated by the five HEZs (ordered from north to south): Upper Ayeyarwady, Chindwin, Middle Ayeyarwady, Lower Ayeyarwady, and Delta.

3.2 Population Growth and Distribution

Population size and composition as well as population density, growth, and migration are important for the assessment of socio-environmental pressures on natural resources and for socioeconomic potential. As such, demography sets the backdrop and must be considered in all river basin assessments and development planning. Based on 2014 census population figures for townships, it is calculated that the total population of the Ayeyarwady Basin is approximately 33.2 million, which is 64% of Myanmar's population. Of these, 15.9 million are male and 17.3 million female, in 7.2 million households that comprise 66% of all of Myanmar's households. The urban population of the Ayeyarwady Basin is 10.8 million, or 73% of Myanmar's urban population. The Ayeyarwady Basin's rural population is 22.3 million people. Yangon is included in these figures, with a population of 6.3 million, of which 4.9 million is urban.

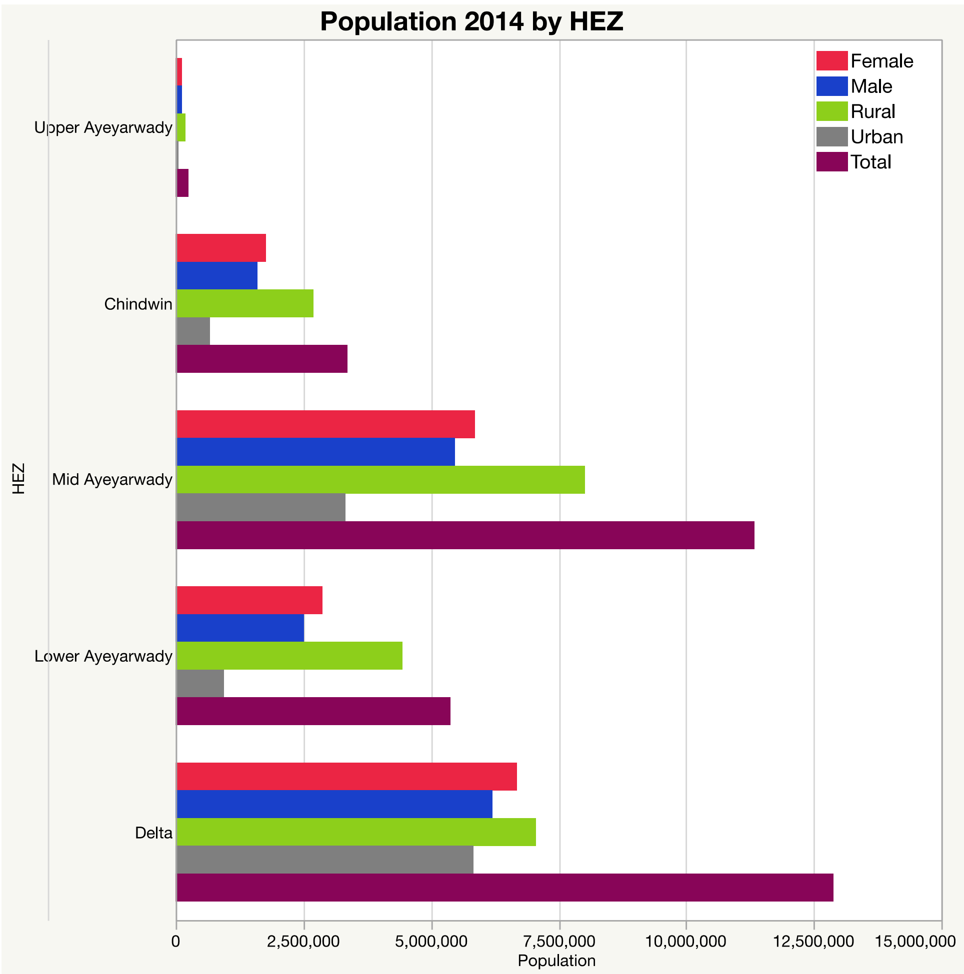


Figure 6 - Population - female, male, rural, urban, and total, by HEZ *(UNFPA, 2014)*

Females outnumber males by 1.4 million in the Ayeyarwady Basin, a trend which is also found at the Union level, where females outnumber males by 1.83 million. Sex ratio is discussed in Section 2.1.1. The urban population of 10.8 million accounts for 73% of the total urban population in Myanmar, and the rural population of 22.4 million accounts for 63% of the rural population.

Table 11 - Population in the Ayeyarwady Basin by hydro-ecological zones (UNFPA 2014)

HEZ	State/region	Total population	Total population male	Total population female	Urban population total	Rural population total	Number of households
Upper Ayeyarwady	Kachin	245,090	122,428	122,662	52,375	192,715	43,388
Chindwin	Chin	215,930	104,264	111,666	56,301	159,629	39,167
	Kachin	60,019	31,979	28,040	37,415	22,604	8,528
	Magway	623,284	281,486	341,798	49,496	573,788	141,417
	Sagaing	2,467,029	1,184,638	1,282,391	528,688	1,938,341	485,992
Middle Ayeyarwady	Kachin	1,337,732	700,946	636,786	502,578	835,154	217,449
	Mandalay	5,447,226	2,605,105	2,842,121	2,028,748	3,418,478	1,156,905
	Sagaing	2,858,318	1,332,311	1,526,007	382,647	2,475,671	610,865
	Shan (North)	1,257,166	614,534	642,632	333,225	923,941	261,807
	Shan (South)	438,913	219,378	219,535	75,904	363,009	94,727
Lower Ayeyarwady	Ayeyarwady	96,083	45,623	50,460	19,495	76,588	26,857
	Bago (West)	1,210,613	577,298	633,315	253,850	956,763	315,066
	Chin	64,093	30,040	34,053	15,664	48,429	12,499
	Magway	3,293,771	1,532,488	1,761,283	538,535	2,755,236	778,360
	Mandalay	718,497	323,262	395,235	114,688	603,809	166,286
Delta	Ayeyarwady	5,790,109	2,818,213	2,971,896	794,407	4,995,702	1,395,954
	Bago (West)	762,620	364,366	398,254	122,009	640,611	191,694
	Yangon	6,336,616	3,018,027	3,318,589	4,919,822	1,416,794	1,341,103
All	All	33,223,109	15,906,386	17,316,723	10,825,847	22,397,262	7,288,064

3.2.1 *Overview of trade*

As is often the case with developing countries, Myanmar is running an increasingly significant current account deficit as it seeks to up-grade its capital stock and producers invest heavily in capital goods. This is not uncommon for an economy which is newly liberalising, but it can place national finances under strain and presents the question of how to finance the needed investment. The deficit has been exasperated in recent years due to falling demand for the commodities that still dominate Myanmar's exports, resulting in falling export prices and volumes. This serves to emphasise the continuing importance of the role played by natural resource sectors (World Bank, 2016b).

Nevertheless, the longer-term trend in exports shows rapid annual growth of approximately 13% over the 2001 - 2014 period (Figure 7). The most rapidly growing exports have been that of jade and gems (along with other precious and semi-precious stones and precious metals), which have grown by an average of 23% per annum, and miscellaneous manufactured goods, which have grown at approximately 22.5% per annum over the same period. Base metals (19%) and mineral products (14%) have also seen rapid export growth. Textiles, by contrast have seen export growth over the period of approximately 6%; this growth has been stronger in recent years, and this is likely to be a sector which sees significant growth in the future.

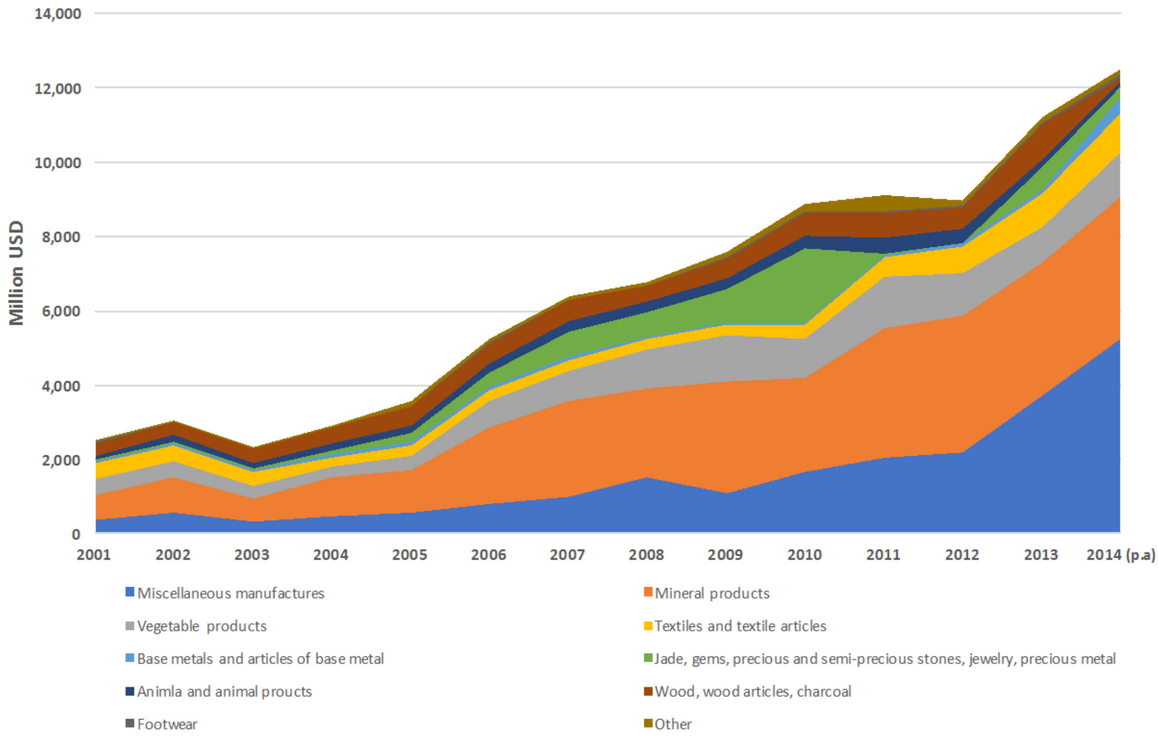


Figure 7 - Main national exports by value (a) and share of value (b) 2001 - 2014

The single largest export sector remains gas from off-shore fields, which was worth approximately US$ 3.6 billion in 2013/2014 or approximately 31% of total export value. The next largest sectors were vegetable products (10%), textiles and garments (8%), base metals (3%), and jade and gems (2%). There are some inconsistencies on the export value of jade and gems, as based on Myanmar Gems Enterprise (MGE) data, these exports could amount to approximately US$ 1.5 billion, as opposed to the US$ 281 million reported in CSO data. The reason for this large difference is not clear. Indeed, more generally it should be borne in mind that the available official figures for exports reported here do not take into account the large illicit trade in precious stones (notably jade and rubies), narcotics and timber, which are all reputedly significant export earners (see Section 2.4.3).

3.2.2 Sex ratio

According to the census main report, the sex ratio of the population (number of males for every 100 females) at the Union level is 93 (UNFPA, 2015). In 1983 and 1973, the sex ratios were 98.6 and 98.8, respectively. At the state and region level, the population of males exceeds that of females only in Kachin State, where there are 108 males for every 100 females. Except in Kayah and Shan States, the census counted more females than males in all states and regions.

According to the census main report, the differences in the sex ratio in Myanmar may be attributed to migration and higher male mortality, starting from adolescence.

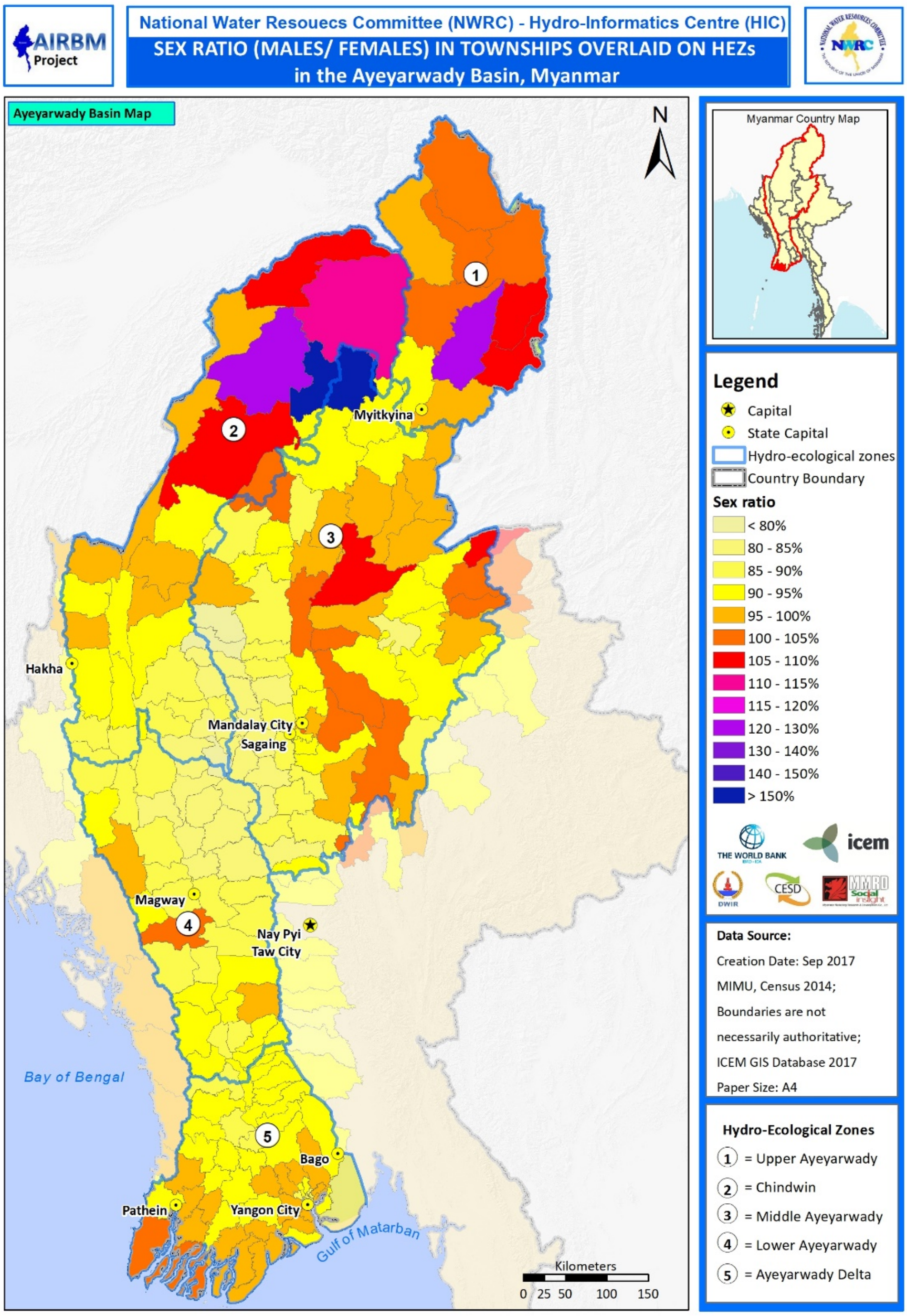


Figure 8 - Sex ratio (males/females) in townships overlaid on hydro-ecological zone

The sex ratio at birth is 102.4 and in all age groups under 15 years there are more males than females. After age 15, the sex ratio declines to below 100 and reduces further with increasing age. As males get older they have a higher mortality rate than females. This pattern is normal and can be observed in most populations.

However, migration must also play a significant role in explaining the large variation in sex ratios found in townships in the Ayeyarwady Basin.

Figure 9 and Table 12 show the quantiles of sex ratios in townships across the five HEZ of the Ayeyarwady Basin. In the Hpakant Township in Middle Ayeyarwady the sex ratio is 174, i.e, there are 174 males per 100 females. On the other hand, in Latha Township in the Delta there are only 74 males per 100 females. Even with the variation found between townships in each HEZ, there is an overall statistically significant difference between HEZs in terms of mean sex ratio, with Upper Ayeyarwady having the highest ratio and Lower Ayeyarwady the lowest.

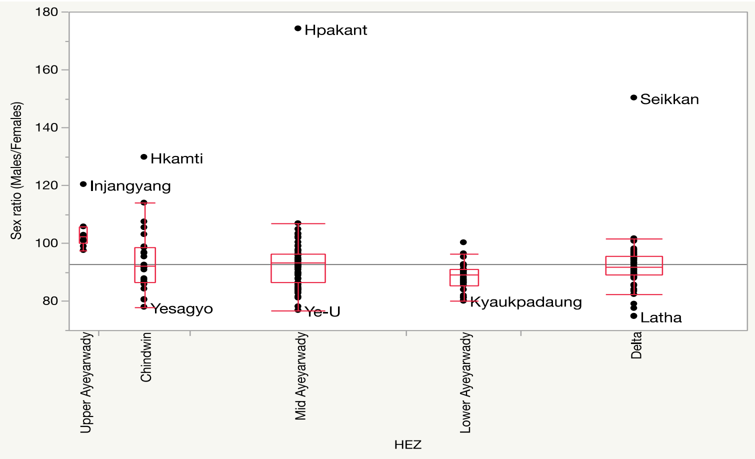


Figure 9 - Sex ratio (males/females) quantiles of townships by hydro-ecological zone with outlier townships marked: *Black dots represent townships. Red boxes show middle two quartiles with the lowest and highest quartiles marked by the other red lines outside the box. The average is the red line across the box.*

Table 12 - Sex ratio (males/females) quantiles of townships by hydro-ecological zone

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Upper Ayeyarwady	97.6	97.6	99.95	102.4	105.8	120.4	120.4
Chindwin	78	80.68	86.55	92.2	98.475	108.15	129.8
Middle Ayeyarwady	76.9	83.62	86.475	93.2	96.5	102.57	174.2
Lower Ayeyarwady	80.1	81.26	85.4	89.4	91.1	93.8	100.3
Delta	74.8	84.1	89.15	91.9	95.65	97.6	150.3

3.2.3 Population growth rate and age structure

The national population change rate has shifted from 2.44% in 1970 to 0.92% in 2017 (Figure 10). Since 1980 Myanmar's population growth has declined rapidly, so that by 1990 it was on par with the average growth rate in East Asia and Pacific. From 1985 onwards it has been separated radically from the average for South Asia (Figure 11).

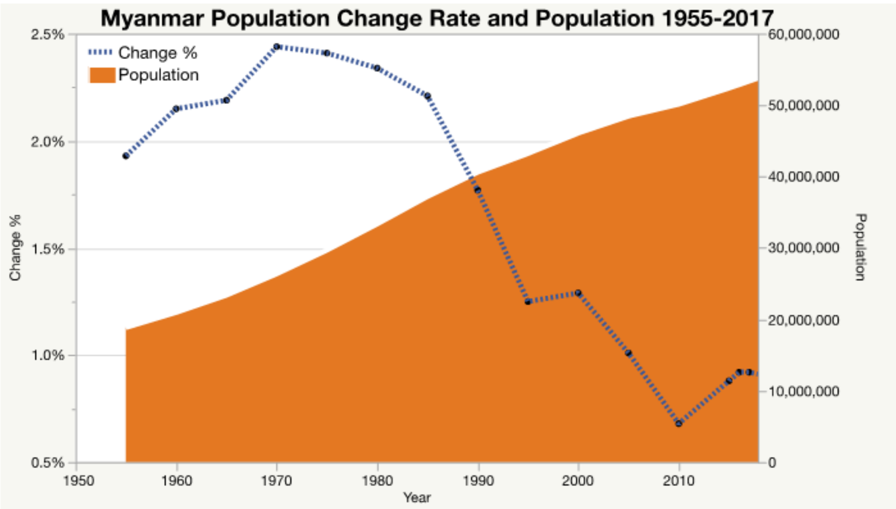


Figure 10 - Myanmar population change rate and population 1955 – 2017: *Elaboration of data by United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2017 Revision (Worldometers, www.Worldometers.info).*

Figure 11 - Population growth rates for Myanmar, South Asia, East Asia, and Pacific *(World Bank 2017b)*

In Myanmar as a whole, a rapid decline in mortality began in the early 1950s. From 1950 to 1955, the crude death rate dropped from 46.8 per 1,000 population to 20.7 per 1,000. The decrease in mortality was not accompanied by a decrease in fertility resulting in approximately 2.5 percent per annum natural growth through the 1950s and the beginning of the 1960s and with high growth rates continuing until 1970 (Thematic Report on Population Dynamics, 2017).

Forecasting on the basis of World Bank time series data on national birth rate, it would seem that the decreasing trend that began in approximately 1970 is likely to continue from the present level of approximately 17 births per 1,000 population per year to 10 births per 1,000. The death rate has also decreased, but has flattened out and is forecasted to reach a stable level of approximately 7 deaths per 1,000 population per year. The natural population change rate has gone from 25 in 1969 to just below 10 in 2014. The forecast is that the decrease will continue, even with a possibility of a negative growth rate in 2035.

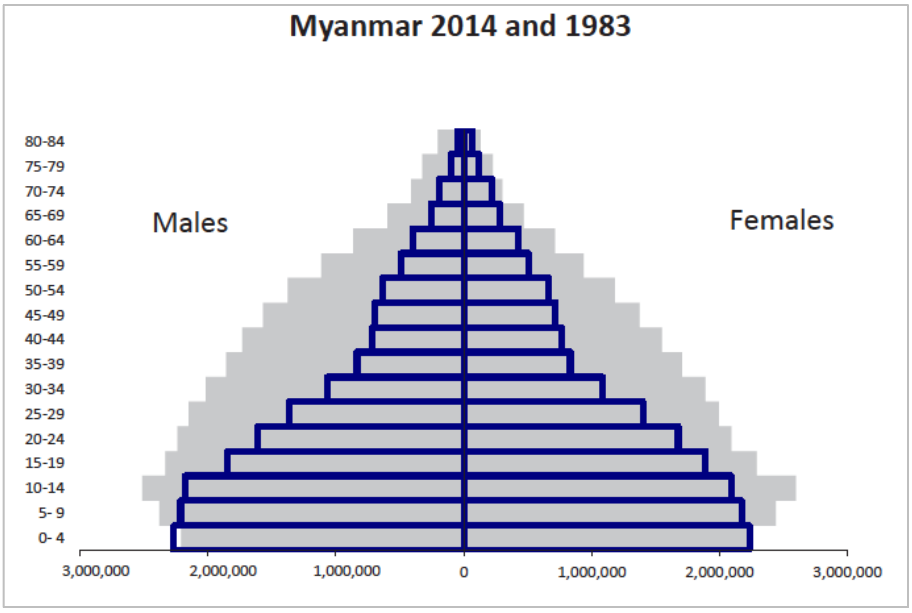


Figure 12 - Population pyramids of 2014 and 1983 compared Grey shape is 2014 (UNFPA, 2015).

The bottom of the population age and sex pyramid in 2014 was narrower than in 1983 (Figure 12), which is evidence that Myanmar, as most developing countries, is in a demographic transition towards a more equal balance of all age groups. The large number of youth between 15 and 30 years old, some scholars infer, is a result of pro-nationalist policies in the past (May and Brooke, 2014). However, emphasis on birth spacing and limiting began in approximately 1992, when the government initiated a birth spacing project, which by 1995 covered 33 townships and by 2011 covered 132 of the country's 320 townships (Searo.who.int, 2014; PubMed, 1994). The program is likely to have contributed to the narrowing of the population pyramid base under the age of 15.

There are more females in the age brackets from 15 years of age and up, while there are more boys under 15 years of age. Though ultrasound-scanning of pregnant women has become widespread over the past 10 years, abortion is illegal and against the Buddhist religion, so an active preference for boys would not appear to be the explanation for this phenomenon. A draft reproductive health policy was debated in 2001 and 2003, but has not yet been finalized and officially adopted.

The available growth rate estimations from Census 2014 are by state/region and as such are not transferable to the Ayeyarwady Basin or the HEZs as discussed in the introduction. However, the growth rates in the state/regions can inform estimations of the growth rate in the Ayeyarwady Basin as a whole and in the HEZ. For example, in the Ayeyarwady Region the growth rate according to the census will be -0.07 in 2020 and -0.23 in 2025, in effect resulting in a decrease in the population of that region by approximately 130,000 people between 2015 and 2030. Kachin, on the other hand, had a growth rate of 1.87 in 2015, which is expected to decrease to 1.7 in 2025.

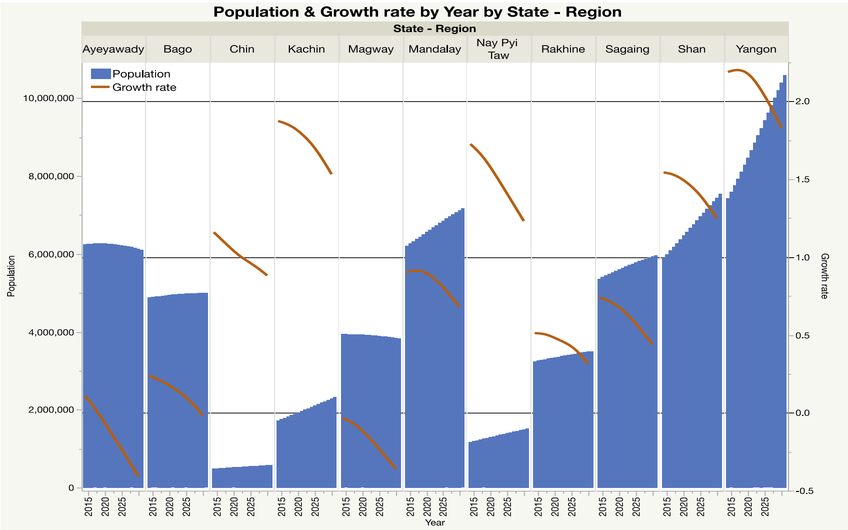


Figure 13 - Population growth rate and projections for 2014 - 2032 by state/region: *(Thematic Report on Population Projections for The Union of Myanmar, States/Regions, Rural and Urban Areas, 2014 to 2050, Census Report Volume 4-F)*

Table 13 - Population growth rate and projections for 2015, 2020, 2025, and 2030 *(UNFPA, 2017c)*

	2015		2020		2025		2030	
State/region	Growth rate	Population	Growth rate	Population	Growth rate	Population	Growth rate	Population
Ayeyarwady	0.08	6,262,164	-0.07	6,270,864	-0.23	6,229,061	-0.41	6,135,794
Bago	0.23	4,896,520	0.18	4,948,959	0.1	4,985,346	-0.02	4,999,430
Chin	1.14	497,009	1.04	525,062	0.96	552,117	0.88	578,431
Kachin	1.87	1,762,901	1.81	1,933,705	1.7	2,112,673	1.53	2,292,682
Kayah	2.16	297,162	2.05	330,356	1.92	365,066	1.77	400,663
Kayin	0.55	1,575,826	0.52	1,618,264	0.57	1,662,013	0.62	1,712,637
Magway	-0.04	3,944,972	-0.12	3,932,063	-0.23	3,900,467	-0.36	3,845,976
Mandalay	0.91	6,274,139	0.9	6,566,720	0.81	6,857,508	0.68	7,122,580
Mon	-0.58	2,034,439	-0.51	1,979,330	-0.43	1,932,256	-0.38	1,893,405
Nay Pyi Taw	1.71	1,196,717	1.58	1,300,303	1.41	1,402,216	1.23	1,499,213
Rakhine	0.51	3,266,405	0.48	3,349,917	0.43	3,428,229	0.31	3,495,118
Sagaing	0.73	5,411,440	0.68	5,608,752	0.57	5,790,087	0.44	5,942,547

State/region	2015		2020		2025		2030	
	Growth rate	Population	Growth rate	Population	Growth rate	Population	Growth rate	Population
Shan	1.54	6,001,082	1.49	6,477,329	1.4	6,967,504	1.25	7,450,683
Tanintharyi	0.87	1,434,723	0.86	1,498,370	0.86	1,564,191	0.81	1,631,909
Yangon	2.2	7,595,018	2.18	8,477,923	2.03	9,429,378	1.83	10,397,969

3.2.4 Population density

The most accurate and highest resolution population data are township data from Census 2014. Though there is large variation in population density within the HEZs, it is clear that population density increases dramatically from north to south, from a median of 2.2 persons per km² in the Upper Ayeyarwady, 34.6 in the Chindwin, 94.1 and 99.9 in Middle and Lower Ayeyarwady, to 334.2 in the Delta (Table 14, Figure 14)

Table 14 - Population density quantiles in hydro-ecological zones *(UNFPA 2014, township area calculated in GIS from MIMU GIS layers)*

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Upper Ayeyarwady	0.4	0.4	0.7	2.2	7.9	25.1	25.1
Chindwin	3.8	5.7	14.0	34.6	113.8	214.3	552.2
Middle Ayeyarwady	9.4	29.8	42.9	94.1	159.6	658.4	16,220.1
Lower Ayeyarwady	8.6	20.6	61.3	99.9	160.2	188.4	320.0
Delta	72.8	127.5	209.5	334.2	13,937.4	33,161.1	53,930.2

Though population density varies significantly between the HEZs, there are a number of urban townships with population densities above 100 persons per km² in each HEZ, except in the Upper Ayeyarwady.

In Chindwin, there are 8 townships with more than 100 persons per km², in Middle Ayeyarwady 32, in Lower Ayeyarwady 18, and in the Delta 68 such townships with high population density (Table 15).

Table 15 - Number of townships with the five highest percentiles population densities by hydro-ecological zone and state/region *(UNFPA 2014)*

HEZ	State/region	Number of townships with the five highest percentiles population density					
		2,409 - high	244.8 - 2,409	169.1 - 244.8	133.6 - 169.1	99.28 - 133.6	All
Chindwin	Magway			1		1	2
	Sagaing		1	2	2	1	6
	All		1	3	2	2	8
Middle Ayeyarwady	Mandalay	5	5	2	6	5	23
	Sagaing		2	1	3	2	8
	Shan (South)					1	1
	All	5	7	3	9	8	32
Lower Ayeyarwady	Bago (West)		1	2	2	1	6
	Magway			2	2	5	9
	Mandalay				2	1	3
	All		1	4	6	7	18
Delta	Ayeyarwady		7	9	3	4	23
	Bago (West)		1	1	2	2	6
	Yangon	30	5	3	1		39
	All	30	13	13	6	6	68
All	**All**	**35**	**22**	**23**	**23**	**23**	**126**

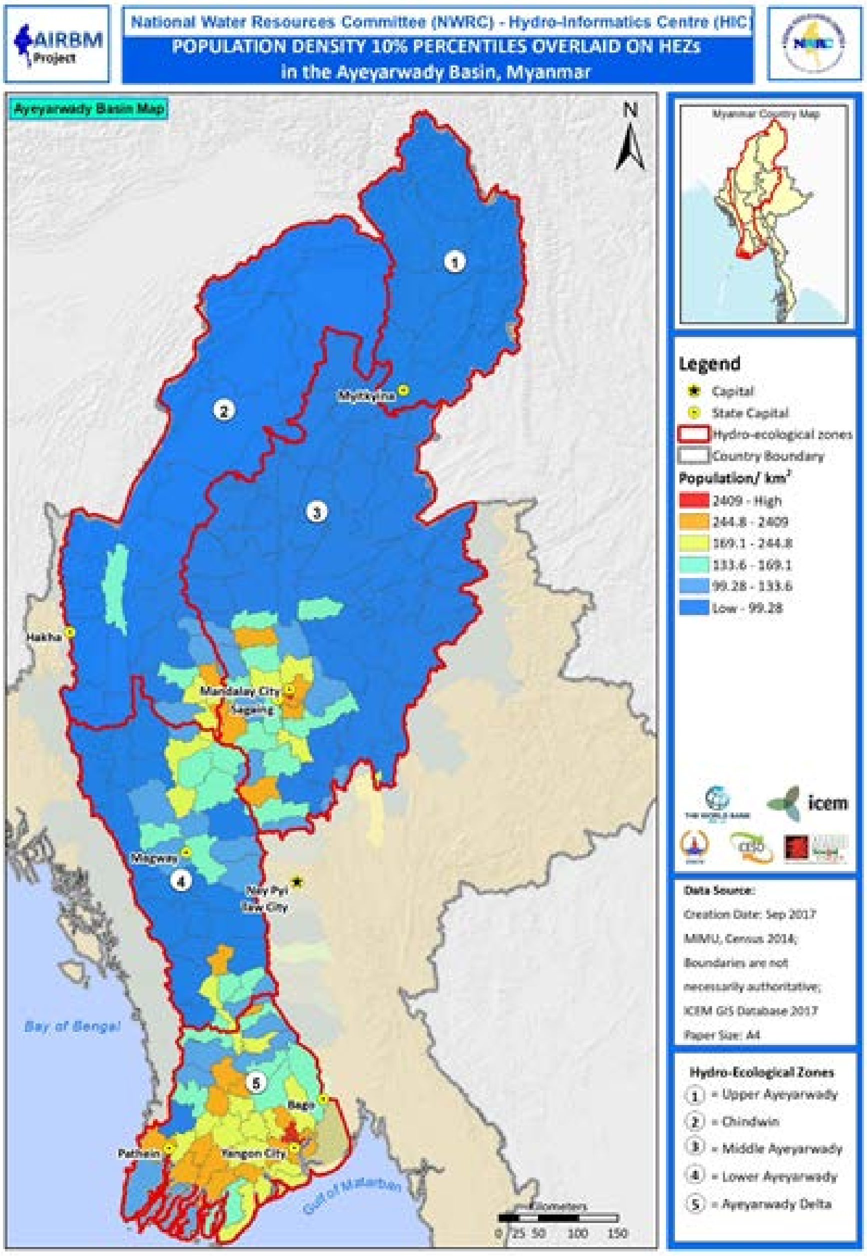


Figure 14 - Population density 10% percentiles overlaid on hydro-ecological zone

3.3 Population movement

3.3.1 *Migration*

The level of internal migration in Myanmar is similar to that of neighbouring countries (UNFPA 2017b). A total of 3.7 million people reported to have migrated to their present place of residence from another state, region, or division within Myanmar in the Census 2014. People migrate mainly for employment or in search of employment. International Labour Organiastion (ILO) estimates that internal labour migration has steadily increased and is likely to continue to increase. An ILO survey of labour migration in the whole country found that the migrating respondents were 66% male and 34% female (Rogovin, 2015). Sixty-two percent of respondents had migrated for work across state/region boundaries. Though the respondents were more likely to migrate to the same type of area that they originated from - either rural or urban - migration from rural to urban areas was more common for those migrating across state/regions boundaries. All respondents migrated for work due to a stated need for money or lack of employment opportunities in their origin area, although some respondents also stated additional reasons for migrating.

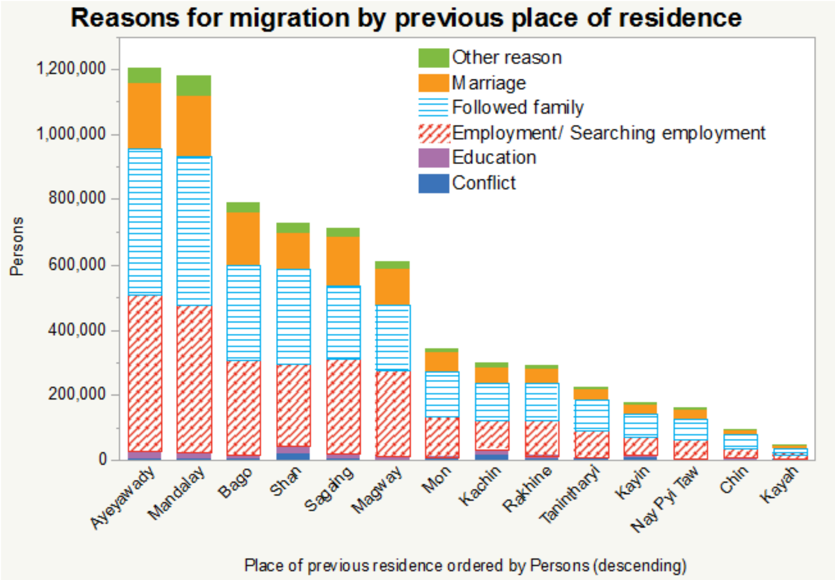


Figure 15 - Reasons for migration *(UNFPA 2014 [excluding Yangon])*

The mandate for managing internal labour migration rests with the Ministry of Labour, Employment, and Social Security, through its Labour Exchange Offices (LEOs). Enterprises in the public and private sectors are required to inform a LEO of vacancies. LEOs provide labour cards to potential workers and maintain information on their education level and employment history in order to place them in an appropriate vacancy. In fiscal year 2013 - 2014, a total of 417,589 workers were placed into jobs via this system.

In 2015, it was reported that there were 20 pieces of labour legislation in effect at that time: five enacted between 1923 and 1948 (during the British colonial era), five between 1951 and 1959, one in 1999 and seven between 2011 and 2014. Several other laws have some relevance, such as the Anti-Trafficking in Persons Law (2005) and the Ward or Village Tract Administration Law (2012). According to this body of laws, Myanmar workers should be afforded a wide range of rights, benefits, and protections (Rogovin, 2015).

Based on available census data,[8] it must be concluded that there is negative net migration, or out-migration, from the Ayeyarwady Basin as a whole. The mean net migration rate per 1,000 population of districts which are within the Ayeyarwady Basin and those that are outside strongly indicates that there is out-migration from the Ayeyarwady Basin. Figure 16 shows the mean values of all districts of total net migration and by sex, with 95% confidence interval bars which indicates the variation between districts in each group. All three means - total, male, and female - of net migration in districts in the Ayeyarwady Basin are negative at approximately -20, with the 95% confidence interval between -34 and -9. In comparison, the means of districts outside the Ayeyarwady Basin are all positive at approximately 10, though the confidence interval shows a large spread from 35 to -10 among districts.

[8] Census data is believed to be more reliable than other surveys on migration despite its limitations, which are the exclusion of seasonal migration of fewer than 6 months and intra-township movement, as well as the exclusion of over 1 million people classified as non-enumerated population. Analysis of census information reveals that an estimated total of 1,206,353 people were not enumerated in parts of Rakhine State (those that self-identified as ‘rohingya’), Kachin State (where an estimated 97 villages are controlled by the Non-State Armed group Kachin Independent Organisation), and Hpa Pun Township in Kayin State. This represents 2.34 % of the population.

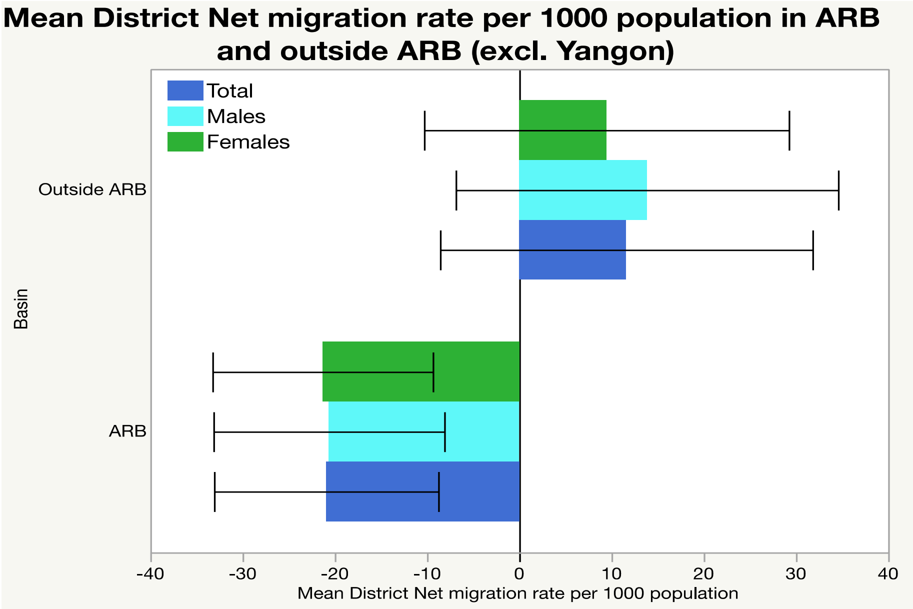


Figure 16 - Mean district net migration rate per 1,000 population in the Ayeyarwady Basin and outside (excluding Yangon): *Each error bar is constructed using a 95% confidence interval of the mean (UNFPA 2017b; calculations of district means in and outside of the Ayeyarwady Basin by team).*

a) Intra-basin migration patterns

According to the Census 2014, the districts with a high volume of outmigration are concentrated in the Ayeyarwady Region. All six districts of Ayeyarwady lost migrants to districts in Yangon in the five years prior to the census (UNFPA, 2017b). The Ayeyarwady continues to lose population through migration to the city of Yangon. In the top 20 migration flows, only one of the migration flows between districts did not involve Yangon. This was the movement of 24,500 migrants from Myingyan District to Mandalay District, both of which are in Mandalay Region. This flow is an example of movement from poor, primarily rural districts, to the closest more developed urban areas. The policy of developing IZs appears to be a powerful instrument influencing the direction of migration attracting migrants to work within the zones.

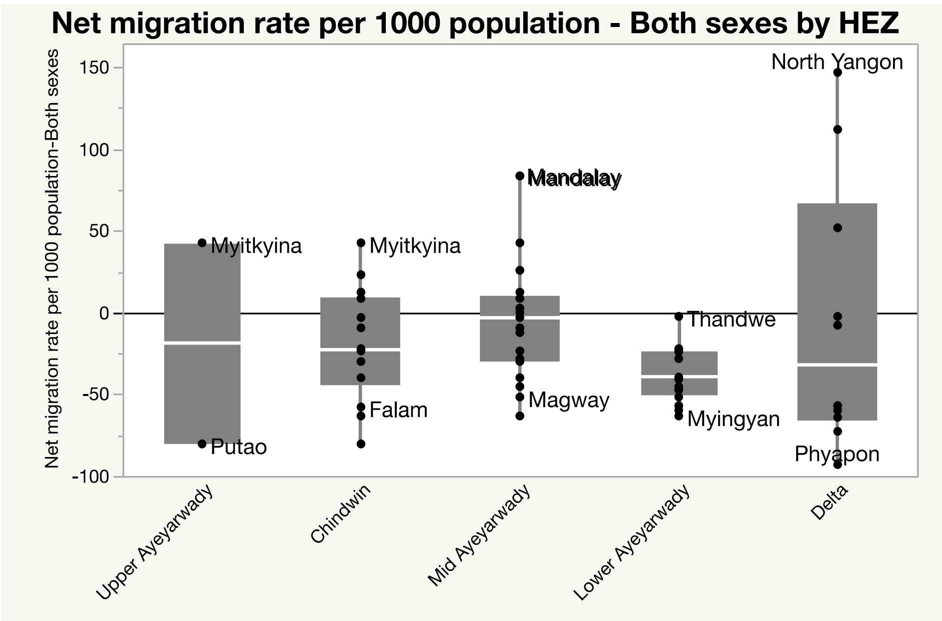


Figure 17 - Net migration rate per 1,000 population by hydro-ecological zones *Townships that appear more than one time are split between several HEZs (UNFPA, 2014).*

The Census 2014 elicited that there has been a decline in rural to urban migration from 24.7% in 2007 to 9.5% in 2014 of all migration flows. The Census report on migration mentions that this pattern is unusual when viewed from a regional or international perspective, but points to limitations in data collection as a possible explanation.[9] Compared to the four household surveys carried out between 1991 and 2007, in 2014 there was an increase in both urban-to-urban migration from 40.5% in 2007 to 47% of all migration flows, and rural-to-rural migration from 25.6% in 2007 to almost 30%. A large proportion of the urban-to-urban migration is between districts in or just around Yangon. In terms of numbers of inter-basin migrants, the census recorded a total of 6.9 million, composed of 1.7 million people rural-rural migrants, 545,000 rural-urban, 1 million urban-rural and 3.6 million urban-urban migrants. The flows of rural-urban, rural-rural, urban-rural, and urban-urban migrants in the individual HEZs of the Ayeyarwady Basin are shown in Table 16 and Figure 18.

Table 16 - Rural-urban migration flows by hydro-ecological zone - lifetime migrants by 2014 *(UNFPA 2017b)*

		Destination		
HEZ	**Origin**	**Rural**	**Urban**	**All**
Upper Ayeyarwady	Rural	18,730	4,971	23,700
	Urban	12,802	29,517	42,319
	All	31,532	34,488	66,019
Chindwin	Rural	173,397	30,604	204,001
	Urban	67,731	107,927	175,658
	All	241,128	138,530	379,658
Middle Ayeyarwady	Rural	646,668	178,530	825,198
	Urban	368,723	800,685	1,169,408
	All	1,015,391	979,215	1,994,606
Lower Ayeyarwady	Rural	335,613	95,000	430,613
	Urban	77,862	191,333	269,195
	All	413,475	286,333	699,808
Delta	Rural	530,654	236,745	767,398
	Urban	534,974	2,513,996	3,048,970
	All	1,065,627	2,750,741	3,816,368
All	**All**	**2,767,153**	**4,189,306**	**6,956,459**

[9] Migration, as defined in the Census 2014, only included persons living in conventional (private) households at the time of data collection and no migration data were obtained from institutions. Many migrants who move reside in worker dormitories, many of which are located in or near Yangon; however, they would not be defined as migrants (Thematic Report on Migration and Urbanization, Census Report, Volume 4-D, December 2016).

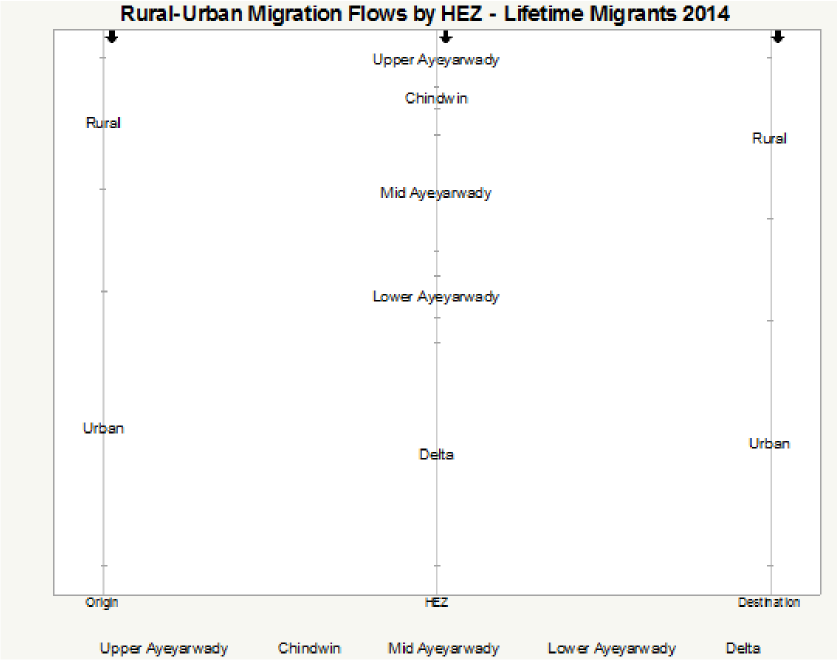


Figure 18 - Rural-urban migration flows by hydro-ecological zone, lifetime migrants by 2014: *Number of migrants in districts that are in more than one HEZ have been divided by the number of HEZs they cover to avoid double or triple counting (UNFPA 2017b)*

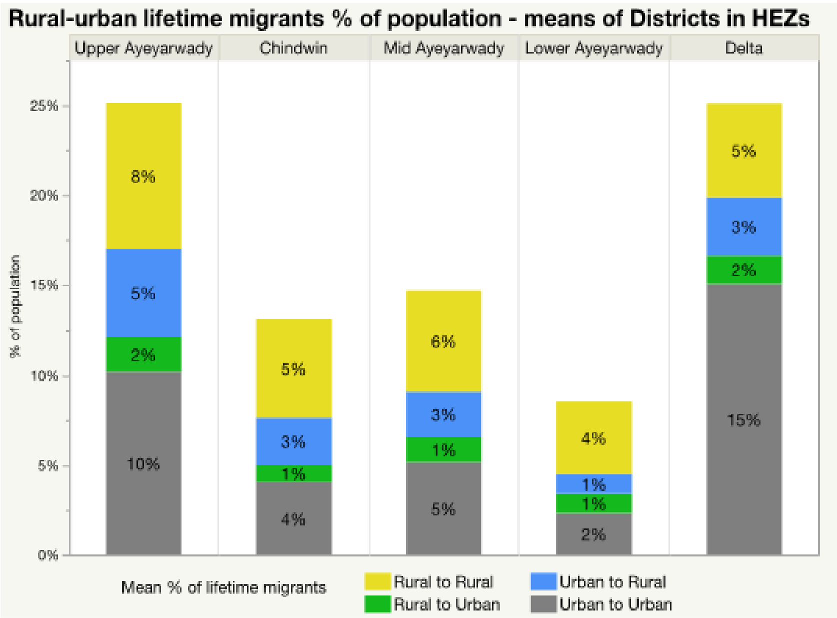


Figure 19 - Rural-urban migration flows, lifetime migrants as mean % of district populations in hydro-ecological zones *(UNFPA 2017b)*

A study of migration focusing on Magway and Ayeyarwady regions, conducted in 2014 - 2015 (Livelihoods and Food Security Trust Fund [LIFT], 2016), identified high levels of migration, with approximately one in four households in Ayeyarwady, and one in five in Magway affected. Migration had increased significantly in recent years, especially since the beginning of Myanmar's economic transition in 2011. The study found that migration patterns in Magway and Ayeyarwady have similarities and differences. Similarities between the regions were that family members in landless households were more likely to migrate, which reflects few income-generating opportunities throughout the year and dependence of small- and medium- landholdings. Differences included the observation that in the Ayeyarwady 58% of migrants who moved to Yangon were generally younger and more likely to have only primary- or lower-secondary level education compared with migrants from Magway. People were less likely to migrate from Ayeyarwady unless they had confirmed guarantees of employment.

b) Emigration

At the time of the census in 2014 there was approximately 1 million lifetime emigrants from the Ayeyarwady Basin, with most living in Thailand (421,000 persons), Malaysia (314,000 persons), and in China (100,000 persons). Middle and Lower Ayeyarwady had most emigrants to Thailand, with approximately 314,000 persons.

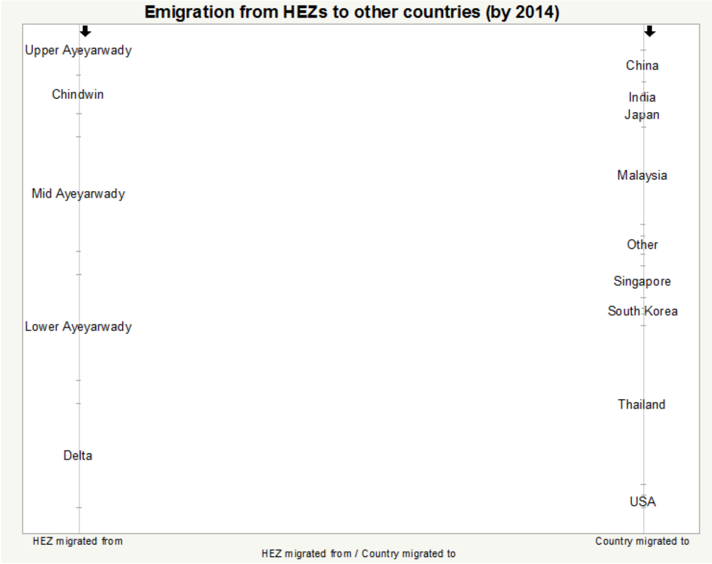


Figure 20 - Lifetime migrants from Ayeyarwady Basin hydro-ecological zones to other countries: *Number of migrants in districts that are in more than one HEZ have been divided by the number of HEZs they cover to avoid double or triple counting (UNFPA 2017b).*

Table 17 - Country of residence of former household members by district of residence of the reporting household, 2014 Census

Country migrated to	HEZ migrated from					All
	Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta	
China	2,801	16,595	52,284	21,875	6,640	100,195
India	126	13,444	8,216	2,067	1,133	24,986
Japan	144	497	1,249	514	5,050	7,453
Malaysia	1,950	67,247	75,204	104,295	65,569	314,265
Other	421	4,682	7,486	6,376	26,763	45,728
Singapore	751	10,335	15,879	12,956	39,617	79,538
South Korea	17	2,474	3,409	3,385	7,505	16,790
Thailand	6,979	35,045	159,388	155,767	64,231	421,410
USA	682	10,424	6,204	3,507	12,000	32,817
All	**13,871**	**160,743**	**329,319**	**310,742**	**228,508**	**1,043,182**

3.4 Conclusions

The overall growth rate of the Ayeyarwady Basin is likely to be similar to the national growth rate of 0.9 in 2017, with significant variation between the HEZs; however, this cannot be calculated on the basis of available data.

The available Census 2014 data are at township level. However, townships are often large and many encompass two of the main river basins, i.e., cover both the Ayeyarwady Basin and other river basins. Similarly, many townships cross the boundaries of the HEZs. This creates some error when aggregating township data for HRZs. Therefore, to avoid error it would be desirable to obtain Census 2014 statistical data with higher resolution at the village or village tract level. However, these data are not available. The solution has been to use the centroids of the township area, in effect converting polygons to points, and overlay these on the HRZ boundaries. This approach clearly places townships in specific HRZs, but it does retain the error in aggregations.

It will be difficult or impossible to get time series data for proper statistical trend analysis. The last census before Census 2014 was 30 years ago. Therefore, key trends and drivers will have to be identified from contextual analysis by expert judgment.

4 LIVELIHOODS

4.1 Introduction

This report looks at a range of indicators relating to household well-being in the Ayeyarwady Basin, represents a synthesis of available secondary data, and seeks to establish key trends and characteristics related to rural livelihoods in the Ayeyarwady Basin. The report is divided into three broad thematic areas: resilience, socioeconomics, and access to services.

The socioeconomic indicators and social trends and drivers in the Ayeyarwady Basin have been grouped into indicators for vulnerability and resilience, which include:

- Dependency ratio in the families and household size;
- Percentages of female-headed households (FHH) that are considered more vulnerable than male-headed households (which may not be the case in Myanmar);
- Poverty by percentages of poor households for the latest available data from 2010;
- Percentages of rates and education levels;
- Number of ethnic groups in the Ayeyarwady Basin;
- Exposure to flooding by location and number of households in a historical perspective; and
- Child health and nutritional status as a key general development indicator and also an indicator for food security.

The analysis continues to cover occupations and livelihoods. Since the census data on occupations have limited information on economic activities, data on households' main sources of income are from a baseline survey carried out in 2012 under the LIFT programme. Landownership data are also from the LIFT Baseline Survey. Households' ownership of means of transportation are analysed by HEZ from data in the census. Fisheries are described on the basis of national statistics since detailed data on fisheries in the Ayeyarwady Basin is lacking. Households' access to roads, sources of lighting, and drinking water and dentation are analysed by HEZ from data in the census.

The objective of the analyses is to take stock of the status and trends of the key socioeconomic characteristics and the development situation of the communities living within the Ayeyarwady Basin, and to analyse the trends to assess their implications for the Ayeyarwady system. The geographical scope is the Ayeyarwady Basin disaggregated by the five HEZs (ordered from north to south): Upper Ayeyarwady, Chindwin, Midle Ayeyarwady, Lower Ayeyarwady, and Delta.

4.2 Policy Context

The most recent available strategy document for rural development is the *Rural Development Strategy for Poverty Reduction Concept Note (5th Draft)*, (MLFRD, n.d.). The strategy for rural development is to embed poverty reduction in a process towards good governance based on self-help village projects identified in a participatory village development plan. Priority will be given to needy regions, with the criteria for selecting areas of priority for support including 1) development need - poverty incidence, 2) beneficiary coverage - expected benefits and population density, 3) operational feasibility, including cooperation and connections of local people, 4) social equity, including equity between ethnic groups, 5) visibility for replicability - areas easily accessible so multiplication of impacts can be achieved, 6) synergy of development intervention and multiplying impacts, including participatory village development plans.

4.3 Indicators of Vulnerability and Resilience

The indicators for social vulnerability and resilience presented in this section are: dependency ratio, percentage of FHH, poverty, exposure to flooding, number of ethnic groups, education and literacy level, and child health and nutritional status.

4.3.1 *Dependency ratio and household size*

Dependency ratio is the number of children under 15 years old and elderly over 64 years old in a family, divided by number of persons between 15 and 64 years old. The ratio is an indicator for vulnerability; the higher it is, the more mouths there are to feed by the working persons in the household.

The overall mean of dependency ratios in households in the Ayeyarwady Basin townships are statistically significantly[10] lower (mean 51) compared to townships outside of the Ayeyarwady Basin (mean 60). However, some townships in the Ayeyarwady Basin have the highest dependency ratios of all in Myanmar. Table 18 shows that the means of dependency ratios in townships in the Upper Ayeyarwady and Chindwin are significantly higher than those in the other HEZs.

Table 18 - Mean household size and total dependency ratio in hydro-ecological zones *(UNFPA 2014)*

Ayeyarwady Basin HEZ	Mean total dependency ratio	Mean household size
Upper Ayeyarwady	73.92	5.57
Chindwin	60.43	4.95
Middle Ayeyarwady	51.71	4.55
Lower Ayeyarwady	51.87	4.03
Delta	45.03	4.26

However, Figure 21 shows a quite large variation within the HEZs, and that the mean dependency ratio in townships in the Upper Ayeyarwady, half of Chindwin, and a small part of the Lower Ayeyarwady is higher than that in the other parts of the HEZs.

[10] Note on the use of the term 'statistical significance': for assessing whether the difference in values for example between Ayeyarwady Basin HEZs is not likely to be a result of chance, statistical significance is defined by Probability >F value. This is defined as follows: the probability of obtaining (by chance alone) an *F* value* greater than the one calculated if, in reality, there is no difference in the population group means. Observed significance probabilities of 0.05 or less are often considered evidence that there are differences in the group means. The statistical results of comparisons between HEZs are not reported in text as this would make it too technical. *F Ratio: Model mean square divided by the error mean square. If the hypothesis that the group means are equal (there is no real difference between them) is true, then both the mean square for error and the mean square for model estimate the error variance. Their ratio has an *F* distribution. If the analysis of variance model results in a significant reduction of variation from the total, the *F* ratio is higher than expected.

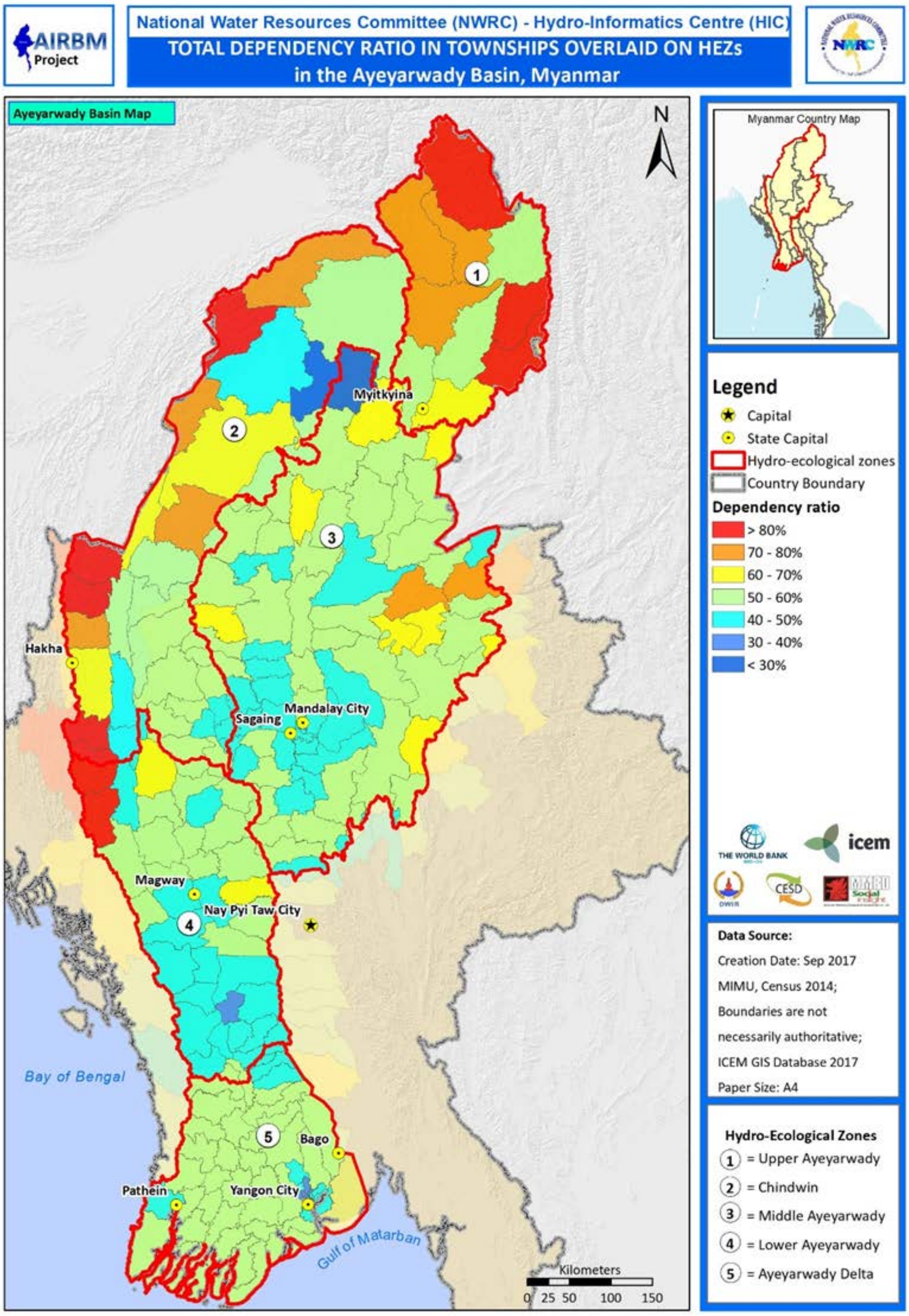


Figure 21 - Total dependency ratio in townships overlaid on hydro-ecological zone boundaries

Household size is an indicator of social and cultural traditionalism versus modernism. Large households are common in traditional societies whereas smaller households, which typically are nuclear families, are the most common type of family structure in modern developed societies. Overall, mean household sizes in the Ayeyarwady Basin (mean 4.46) are statistically significantly smaller than in townships outside the Ayeyarwady Basin (mean 4.64), though there is great variation between townships.

Figure 22 shows the mean household size in Ayeyarwady Basin townships. It is immediately noticeable that household sizes are highest in the north and reduce in size as one moves towards the south.

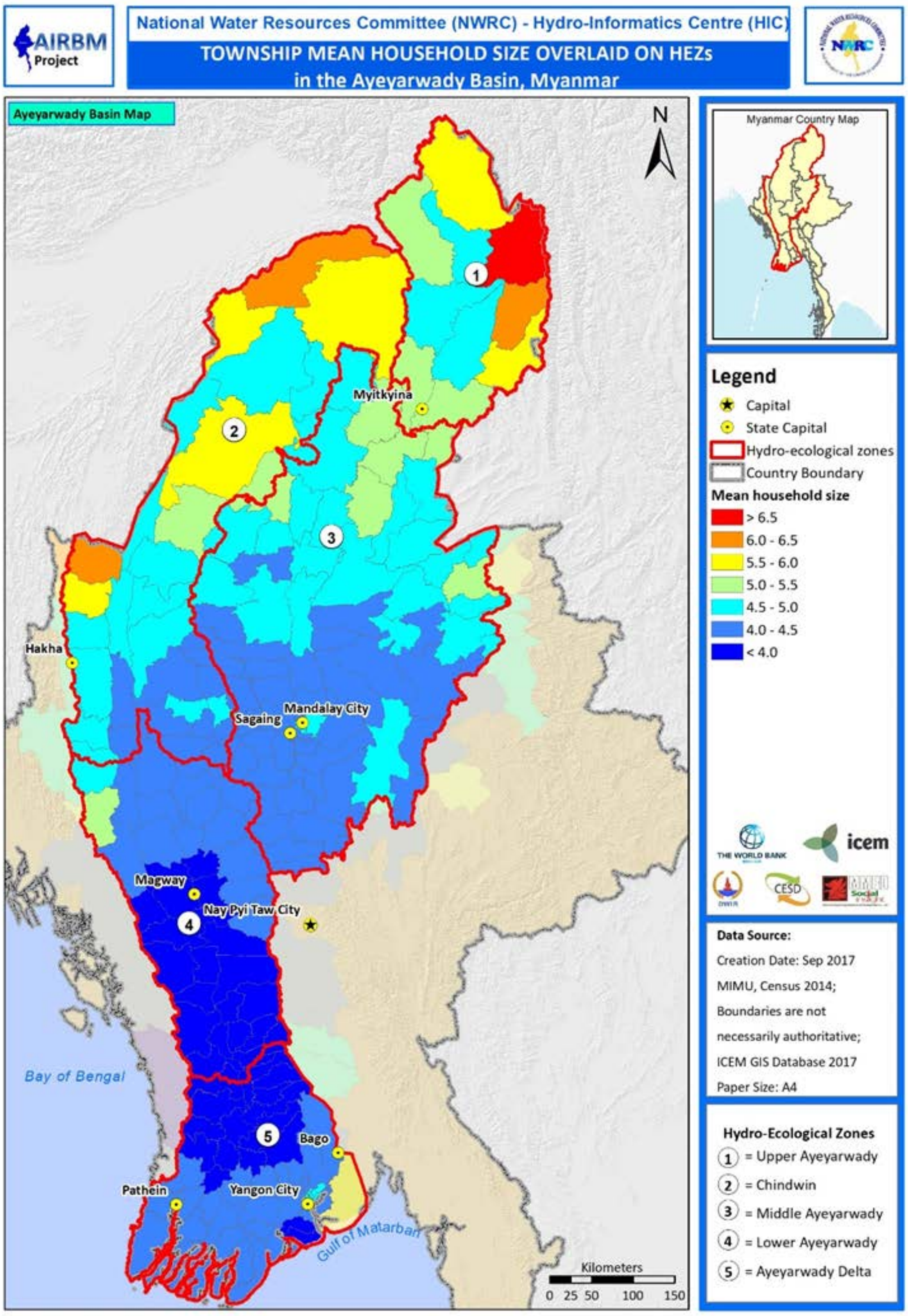


Figure 22 - Township mean household size overlaid on hydro-ecological zone

Household sizes differs significantly between HEZs: the Upper Ayeyarwady has a mean household size of 5.56; Chindwin 4.9; Middle Ayeyarwady 4.5; Lower Ayeyarwady 4.0 and the Delta 4.2.

Figure 23 shows the relationship between household size and dependency ratio presenting a view on two indicators of traditional versus modern family structures.

In this respect, it is evident that the Upper Ayeyarwady HEZ, which is mainly inhabited by the Kachin, has a more traditional social and cultural society compared to the Lower Ayeyarwady and the Delta. The strongest positive correlation between household size and dependency ratio is in the Lower Ayeyarwady HEZ, and secondly in the Chindwin HEZ. In these HEZs there is an almost linear correlation between household size and dependency ratio, which means that the higher the number of family members in a family, the higher the dependency ratio. This is likely to indicate many families with many children, which however is not analysed here. In the Upper Ayeyarwady, household sizes are larger than those in the other HEZs overall but there is no strong relationship to dependency ratio, which indicates traditional large family households. In the Delta, there is a slight inverse correlation between household size and the dependency ratio, indicating the prevalence of smaller sized nuclear families with only the children living at home.

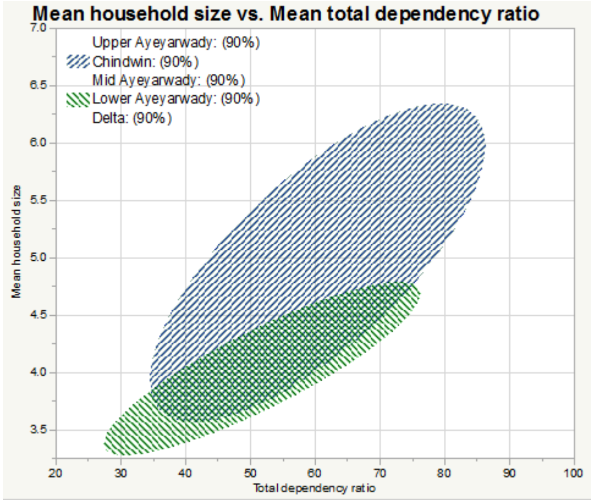


Figure 23 - Distribution and relationship between household size and dependency ratio by hydro-ecological zone *(UNFPA 2014)*

4.3.2 FHH

FHH are considered more vulnerable than male headed households because they often have fewer adults in an economically active age. Overall, the mean percentage of FHH in townships in the Ayeyarwady Basin is slightly, but statistically significantly higher (mean 24.3%) compared to townships outside the Ayeyarwady Basin (mean 22.3%).

A gender focused study based on the Integrated Household Living Condition Assessment (IHLCA) 2009/2010 found that in 72% of FHH, the head was widowed. However, census data does not show a relationship between the percentage of FHHs in townships and proxy poverty indicators such as drinking water source from rivers and stream and house materials made of bamboo. The IHLCA in 2010 found an inverse relationship between poverty and female-headship. The relative proportions of poor and non-poor FHHs were 18% and 21.5%, respectively. IHLCA also found that FHH are more likely to be in urban than rural areas, at 27% versus 19% of household respectively. The IHLCA report offers possible explanations for the lack of relationship between poverty and FHH as receipt of remittance income or because only better-off women, in primarily urban areas, are able to form their own households upon divorce or death of a spouse.

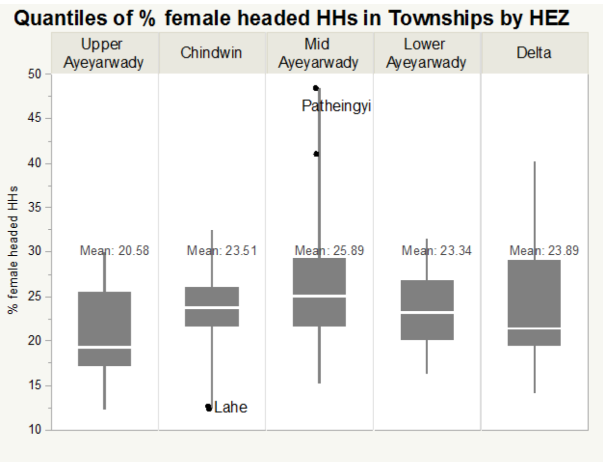


Figure 24 - Quantiles of % FHH in townships by hydro-ecological zone *(UNFPA 2014)*

The Census 2014 found that 23% of all households in Myanmar are female-headed. IHLCA 2009/2010 found 13% of FHH had adult males, and these households were similar to male-headed households in terms of household size, composition, resources, and well-being. However, the 7% of female-headed houses with no adult males were different, with fewer resources and diverse income sources. IHLCA also pointed to regional differences, likely due to high levels of male out-migration from some areas or higher levels of civil unrest that forced men away from their home.

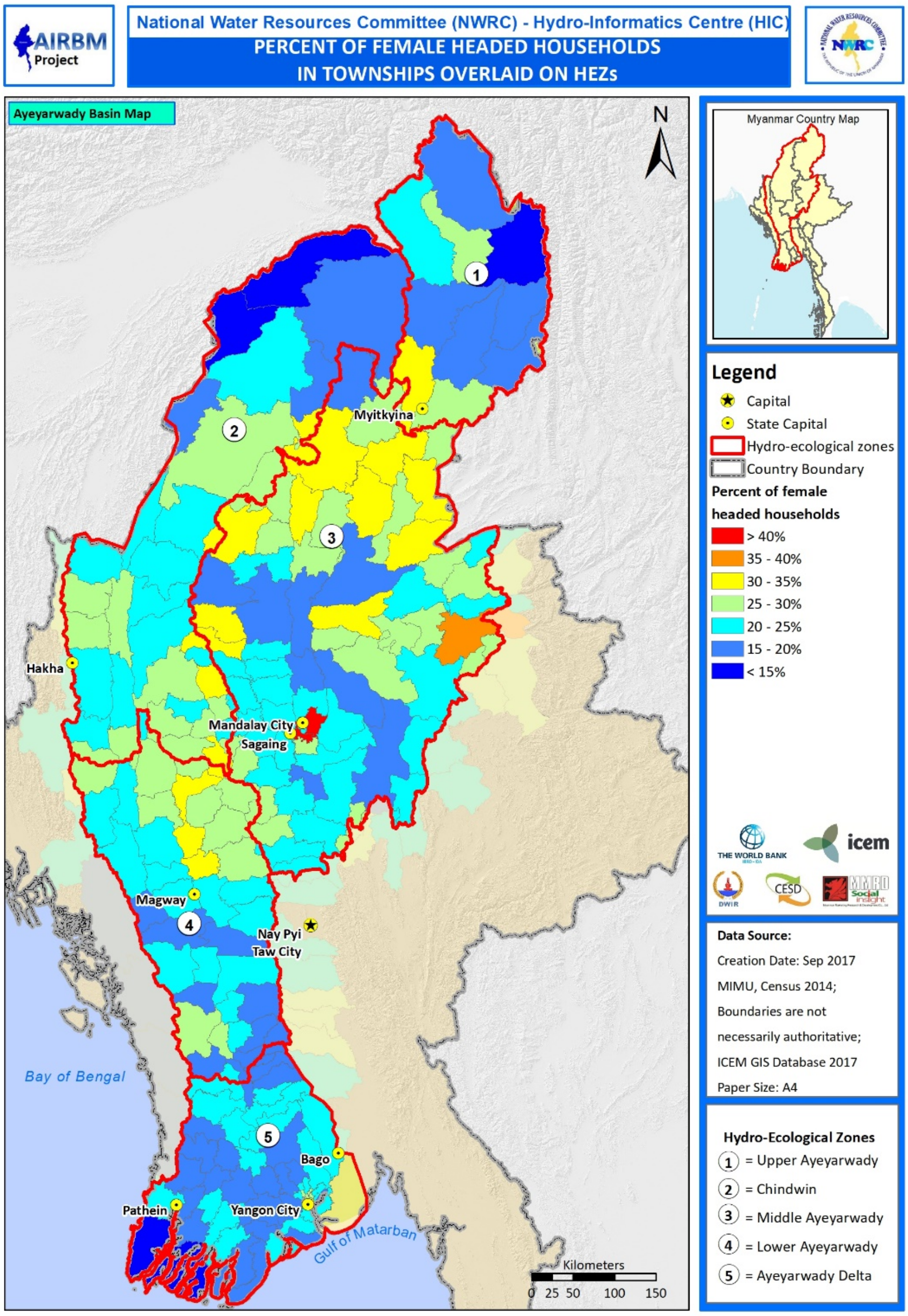


Figure 25 - % FHH in townships overlaid on hydro-ecological zone

4.3.3 Poverty

At the time of writing the present report, no detailed and updated poverty data that can soundly be applied for an analysis of poverty in the Ayeyarwady Basin were available. The Integrated Household Living Conditions Surveys (IHLCS) carried out in 2004/2005 and 2009/2010, reported on poverty levels at state/region level. As discussed in the introduction, it is not statistically sound to apply this level of data to produce poverty rates for the Ayeyarwady Basin and the HEZs as they cross state/region boundaries. However, to get an idea of the poverty levels within the Ayeyarwady Basin and the HEZ, Table 19 shows the poverty and food poverty incidence in 2010 for the states and regions that cover the Ayeyarwady Basin.

Table 19 - Poverty and food poverty incidence, rural and urban 2010 in state/regions covering the Ayeyarwady Basin *(IHLCA, 2010)*

	Poverty			Food poverty		
State/region	*Rural*	*Urban*	*All*	*Rural*	*Urban*	*All*
Ayeyarwady	33.9%	23.1%	*32%*	6.5%	3.8%	*6%*
Bago	18.2%	19.0%	*18%*	1.4%	3.4%	*2%*
Bago (West)	15.9%	15.6%	*16%*	0.3%	0.7%	*0.5%*
Chin	80.0%	52.1%	*73%*	30.8%	6.4%	*25%*
Kachin	30.6%	23.4%	*29%*	5.0%	2.5%	*4%*
Magway	28.2%	15.8%	*27%*	3.8%	2.1%	*4%*
Mandalay	31.6%	14.1%	*27%*	6.5%	2.3%	*5%*
Sagaing	14.9%	16.0%	*15%*	1.1%	2.5%	*1%*
Shan	39.2%	14.1%	*33%*	10.8%	3.5%	*9%*
Shan (North)	43.1%	16.3%	*37%*	11.6%	3.4%	*10%*
Shan (South)	31.2%	8.3%	*25%*	9.8%	3.6%	*8%*
Yangon	28.7%	11.9%	*16%*	4.8%	1.6%	*2%*
Union	*29%*	*16%*	*26%*	*7.7%*	*3.0%*	*5%*

Table 26 shows the poverty incidence overlaid on the HEZ boundaries, and the food poverty incidence in the same manner. The food poverty line has a lower threshold of yearly income per person than the poverty line. The actual (nominal) values of the food poverty and poverty lines per adult equivalent per year, in 2005 and 2010 kyats, were:

	2005	2010
Poverty line	162,136 kyat/US$ 150 per year	376,151 kyat/US$ 290 per year
Food poverty line	118,402 kyat/US$ 110 per year	274,990 kyat/US$ 212 per year

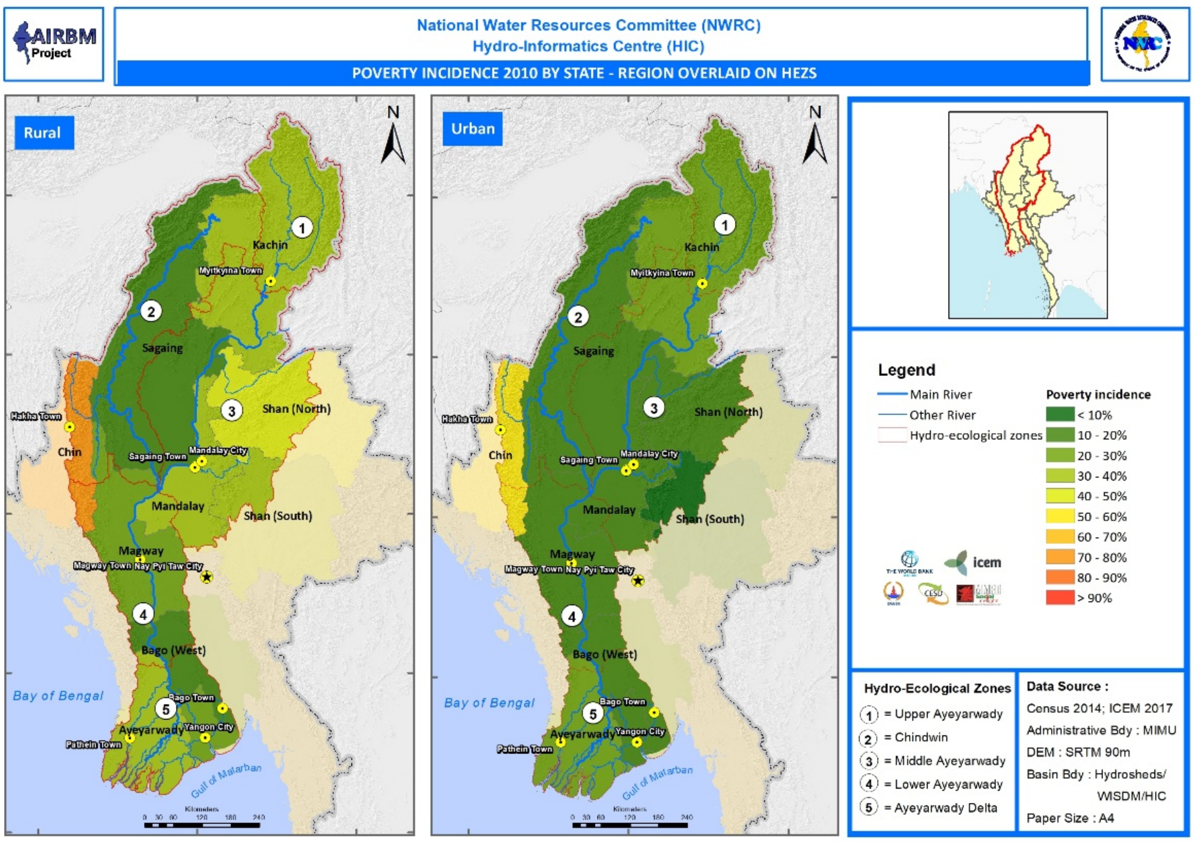


Figure 26 - Poverty incidence 2010 by state/region overlaid on hydro-ecological zone *(IHLCA, 2010)*

Poverty incidence was highest by far in Chin State at 73%, second in Shan North at 37%, third in Shan at 33% and fourth in Ayeyarwady at 32%.

a) Trends in poverty

The most recent available research on poverty in Myanmar that of MFP and World Bank (2017a) based upon a number of household level surveys conducted in 2015. This concludes that overall poverty at the Union level, as estimated by the Government of Myanmar, has decreased from 25.6% in 2009/2010 to 19.4% in 2015. The decline in poverty is seen regardless of how poverty is defined and methodologies are applied. Applying the World Bank methodology, urban poverty declined from 34.6% in 2009/2010 to 19.2% in 2015, while rural poverty declined from 38.5% in 2009/2010 to 28.8% in 2015.

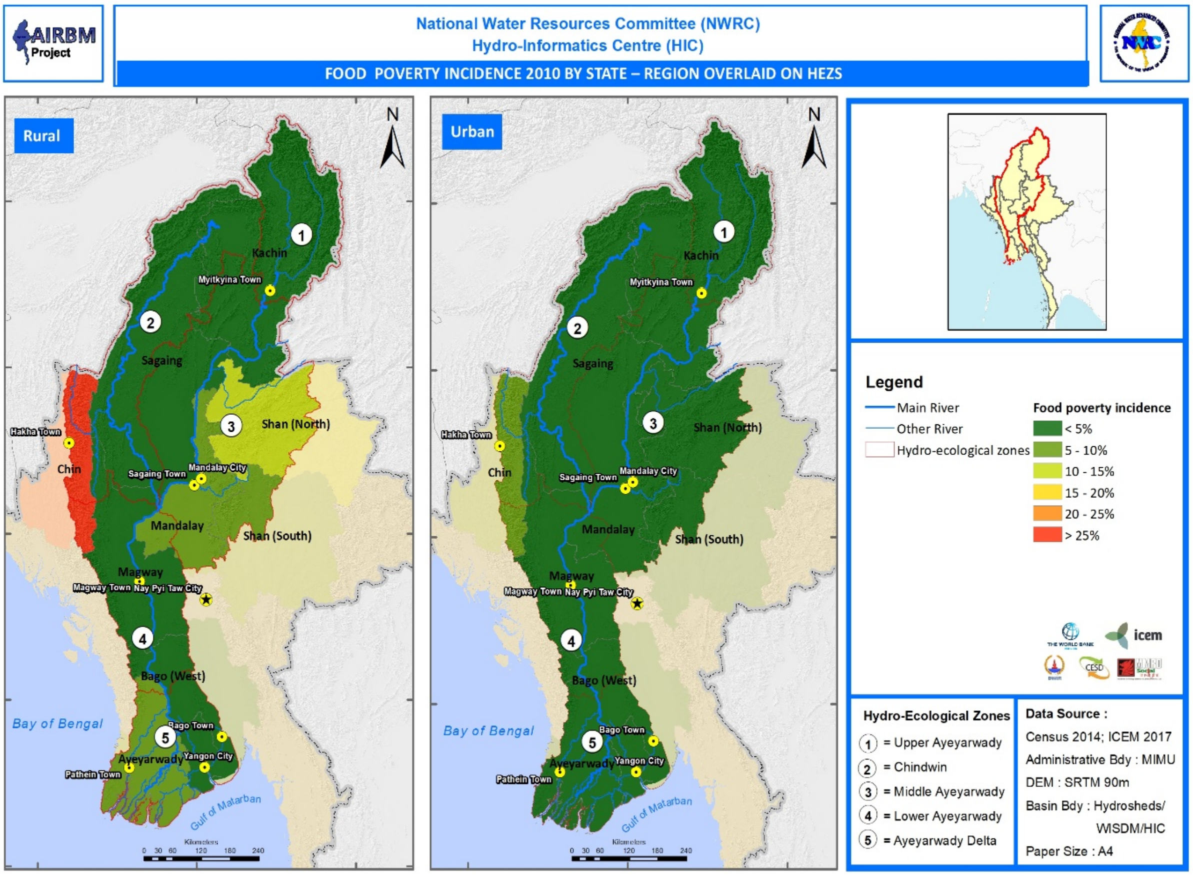


Figure 27 - Food poverty incidence 2010 by state/region overlaid on hydro-ecological zone *(IHLCA, 2010)*

The more rapid decline in urban poverty relative to rural poverty is mirrored in sectoral growth figures, which show a more rapid rate of growth in manufacturing and services than in the agricultural sector over the same period. Standards of living have increased more rapidly in urban areas than they have in rural areas.

In 2013, the United Nations Children's Fund re-examined poverty data from IHLCA (2010) to identify proximate causes of household poverty through regression analysis (Aung et al., 2013). The analysis shows that higher incomes are associated with higher education, more work hours, and male-headed households, while lower incomes are associated with location (i.e., living in Rakhine and Chin states and living in rural areas), households with small children, households with more than three females, and working in the agricultural sector (Figure 28).

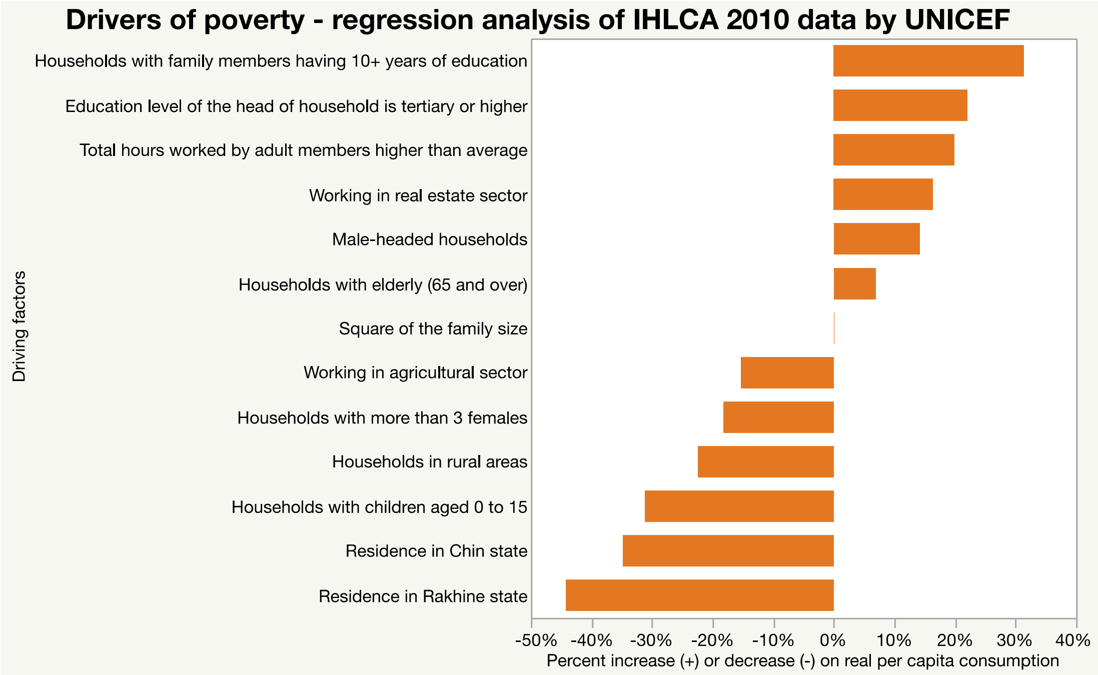


Figure 28 - Drivers of poverty, UNICEF analysis of IHCLA poverty data

b) Poverty dynamics

Many households fluctuate around the poverty line. Every year some households escape from poverty and others fall into poverty. From 2005 to 2010, temporary or transitory poverty affected 28% of all households, versus 10% of all households that were chronically poor during that period of time. Transitory poverty is linked to the dependence of the majority of the population on agriculture and natural resources with the associated vulnerability to floods and droughts, storms and diseases. Data from the 2010 Poverty Dynamics report suggest transitory poverty is close to three times the size of chronic poverty, affecting 28% versus 10% of households. Figure 29 and Table 20 show the percentages of households that became poor, those that left poverty, those that were chronically poor, and the total percentage of poor households in 2010. The three highest percentages of entries into poverty in state/regions covering the Ayeyarwady Basin were in Chin state, Ayeyarwady and Shan South. The three highest percentages of households escaping from poverty were in Magwe region, Kachin state, and Northern Shan state.

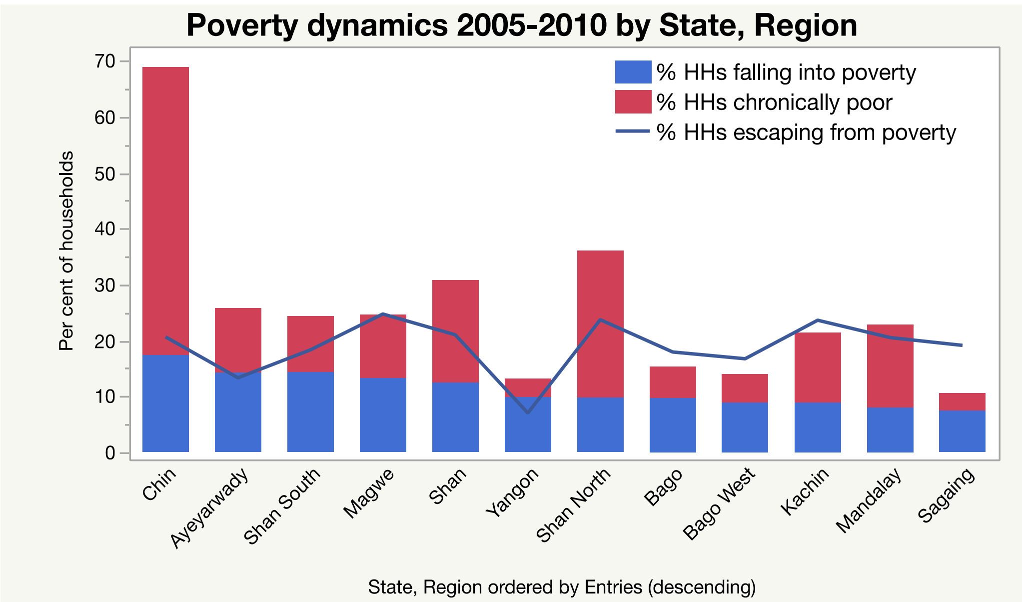


Figure 29 - Poverty dynamics 2005 - 2010 in state/regions covering the Ayeyarwady Basin *(IHLCA, 2010)*

Table 20 - Poverty dynamics 2005 - 2010 in state/regions covering the Ayeyarwady Basin *(IHLCA, 2010)*

State/region	Entries	Escapes	Chronic poverty	2010 poor
	% of HHS			
Ayeyarwady	14.3	13.3	11.5	32.2
Bago	9.7	17.9	5.6	18.3
Bago West	8.9	16.7	5.0	15.9
Chin	17.4	20.6	51.5	73.3
Kachin	8.9	23.6	12.5	28.6
Magwe	13.3	24.7	11.3	27.0
Mandalay	8.0	20.5	14.8	26.6
Sagaing	7.5	19.1	3.1	15.1
Shan	12.5	21.0	18.3	33.1
Shan North	9.8	23.7	26.2	37.4
Shan South	14.3	18.3	10.0	25.2
Yangon	9.9	7.0	3.3	16.1
All	11.2	18.9	14.4	29.1

4.3.4 *Literacy and education*

a) Access to education

Primary education is compulsory in Myanmar; every child from the age of five is required to attend a primary school. The government aims to enable every individual to acquire basic education. Though every child who is eligible is encouraged to attend, school enrolment rate has not reached 100% yet. According to 2011 statistics (UNICEF 2016), the total enrolment rate was approximately 85% but the completion rate was just more than 81% (Table 21).

Table 21 - Education indicators – Myanmar *(UNICEF 2016)*

Education indicator	Value
Pre-primary school participation	
Gross enrolment ratio (%) 2008 - 2012, male	9.9
Gross enrolment ratio (%) 2008 - 2012, female	10.5
Primary school participation	
Net attendance ratio (%) 2008 - 2012, male	89.8
Net attendance ratio (%) 2008 - 2012, female	90.6
Survival rate to last primary grade (%) 2008 - 2012, male	74.8
Survival rate to last primary grade (%) 2008 - 2012, female	93.3
Secondary school participation	
Net attendance ratio (%) 2008 - 2012, male	58.0
Net attendance ratio (%) 2008 - 2012, female	58.6

To promote greater access to, and quality of basic education, the Ministry of Education is implementing a *Thirty-Year Long-Term Basic Education Development Plan (2001 - 2002 to 2030 - 2031)* across Myanmar.

There are three types of schools in Myanmar that offer primary education: public schools, private schools, and religious-run schools. There are more than 41,000 state-run schools (called public schools) in Myanmar. As the land area of Myanmar is just over 677,000 km^2, it is estimated that the farthest distance from home to school is an average of approximately 2 kilometres.

Private-sector schools were accepted from 1948 to 1962, but were eliminated during the socialist era from 1962 to 1988. Since the 1990s, private schools have started developing again. In 2011, the Private School Law was promulgated to enhance private participation in the education sector and 20 private schools so far have been approved from the 67 that applied for permission from the Ministry of Education.

Across Myanmar, religious-run schools still play a significant role in the education system. They offer free education and target orphans or children from poor families who cannot afford to pursue formal education. They follow the official primary curriculum. There are a significant number of schools supervised by Buddhist monks, with more than 1,400 monastic schools in 250 townships throughout Myanmar. The primary school students in these facilities numbered over 160,000 in 2005/2006.

Secondary education is divided into middle schools (standards 6 - 8) and, upon passing the Basic Education Standard VIII Examination, students continue onto high schools, which cover Standards 9 - 10. At the end of Standard 10, students must pass the Basic Education Standard 10 Examination (matriculation exam) in order to continue their educations at a university.

There are 45 universities and colleges and 154 technical and vocational schools. In 2004, the government reported that between 1989 and 2004 the number of colleges and universities increased from 32 to 154 with student enrolment rising from 120,000 to 890,000.

a) Performance in literacy and education

Literacy is measured in respect to the Burmese language, not minority languages, which affects the mean literacy rates in the ethnic minority states and regions, for example in Upper Ayeyarwady which has the lowest literacy rate and is mostly in Kachin State.

The mean literacy rates for males and females above 15 years of age differs by -5.7% points for the Ayeyarwady Basin, showing the general lower literacy of women. The largest difference is in Upper Ayeyarwady at -9.1% points. The mean literacy rate of the urban and rural population differs even more with -19.7% points for rural areas in the Ayeyarwady Basin. Thus, literacy rate is significantly skewed favouring males and urban populations.

Table 22 - Literacy rates - male, female, urban, and rural, by hydro-ecological zone *(UNFPA 2014, team's calculation of mean values by HEZ)*

	Mean literacy rates persons above 15 years of age					
Ayeyarwady Basin HEZ	Male	Female	Difference female-male rate	Urban	Rural	Difference rural-urban rate
Upper Ayeyarwady	84.5	75.4	-9.1	89.1	77.6	-11.5
Chindwin	91.5	83.6	-7.8	93.4	86.0	-7.4
Middle Ayeyarwady	94.1	87.9	-6.2	95.3	82.1	-13.2
Lower Ayeyarwady	96.2	88.7	-7.5	96.1	91.2	-4.9
Delta	97.5	94.6	-2.9	96.9	57.4	-39.5
All	94.8	89.2	-5.7	95.4	75.7	-19.7

With regard to the highest education attainment of persons above 25 years of age in the Ayeyarwady Basin and outside the Ayeyarwady Basin, the only major difference is with respect to the percentage of people without any education, where Ayeyarwady Basin townships have a mean of 13% of household members, and townships outside the Ayeyarwady Basin have a mean of 25% of household members with no education.

There are significant differences between HEZs with regard to education levels. In the Upper Ayeyarwady and Chindwin respectively, 30% and 20% of the population above 25 years of age have no education. However, in the Upper Ayeyarwady a higher percentage has the highest attainment of a middle-school grade, compared to all other HEZs. In the Chindwin, Middle and Lower Ayeyarwady HEZ, between 45% and 50% have primary school as highest attainment. The Delta has the highest percentage (approximately 15%) of persons with high school and university/college degrees (Figure 30, Table 23).

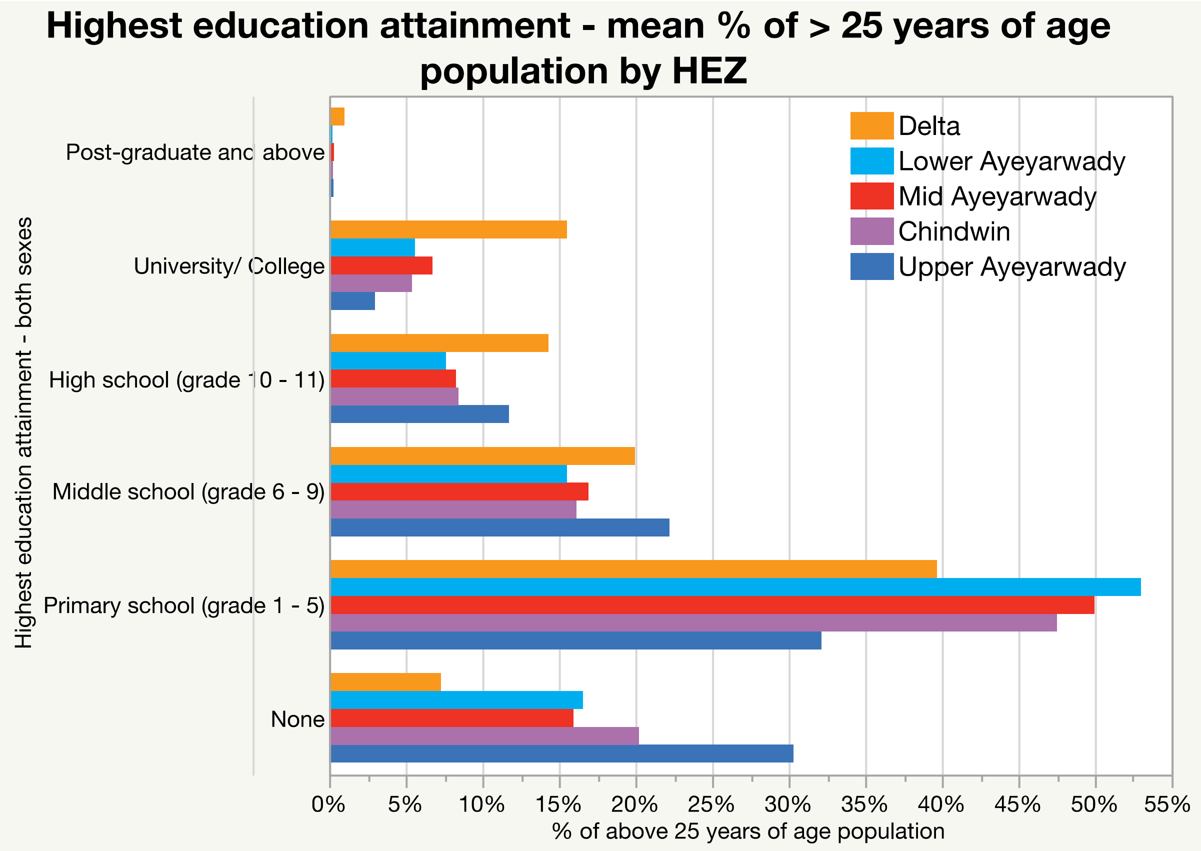


Figure 30 - Highest education attainment, % of above 25 years of age by hydro-ecological zone

Table 23 - Highest education attainment - % of above 25 years of age by hydro-ecological zone *(UNFPA 2014, team's calculation of mean values by HEZ)*

	% of above 25 years of age population									
	Mean					Standard deviation				
Highest education attainment - both sexes	Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta	Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
None	30.3%	20.2%	15.9%	16.5%	7.3%	14.7%	18.5%	11.5%	8.6%	5.1%
Primary school (grade 1 - 5)	32.1%	47.5%	50.0%	53.0%	39.7%	7.2%	15.0%	11.7%	9.7%	19.6%
Middle school (grade 6 - 9)	22.2%	16.1%	16.9%	15.5%	19.9%	6.1%	5.7%	4.6%	2.8%	4.7%
High school (grade 10 - 11)	11.7%	8.4%	8.3%	7.6%	14.3%	4.0%	4.0%	3.8%	2.2%	7.8%
Diploma	0.2%	0.2%	0.2%	0.2%	0.3%	0.2%	0.2%	0.1%	0.1%	0.2%
University/College	3.0%	5.4%	6.7%	5.6%	15.5%	1.4%	2.3%	4.5%	1.9%	13.9%
Post-graduate and above	0.3%	0.2%	0.3%	0.2%	1.0%	0.2%	0.2%	0.4%	0.2%	1.2%
Vocational training	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%
Other	0.1%	1.7%	1.6%	1.2%	1.8%	0.2%	2.1%	1.3%	1.5%	2.8%

4.3.5 Health and access to health services

Life expectancy at birth increased for both males and females between 1980 and 2011. The top five causes of disability adjusted life years in 2010 were lower respiratory tract infections, tuberculosis, diarrhoeal diseases, human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS), and stroke.

The top five risk factors are diet, tobacco smoking, household air pollution from solid fuels, high blood pressure, and high blood sugar. Non-communicable diseases contribute to approximately 40% of deaths in Myanmar. Non-communicable diseases and injuries generally rose between 1990 and 2010, while communicable, maternal, neonatal, and nutritional causes of disability adjusted life years generally declined. Improvements in access to safe water and adequate sanitation have been reported, however, diarrhoea remains among the top five causes of death.

The Ministry of Health (MOH) is the major player in the health sector as a governing agency as well as a provider of comprehensive health care. However, with the evolving political and administrative circumstances, more key stakeholders now play larger roles. Historically, the health system was shaped by the five distinct periods of administrative regimes and political systems. The government used to be the main source of financing, with provision of services virtually free until user charges were introduced in the form of cost sharing in 1993. Since then household out-of-pocket payment has become the main source of finance.

The health system comprises a pluralistic mix of public and private systems both in financing and provision. The Department of Health, one of the seven departments of MOH, is the service provider and is responsible for the regulatory functions of the ministry in protecting the health of the people. The network of hospitals and health centres, which extends down to village level, provides preventive and curative services ranging from primary to tertiary care. Inadequate managerial capacity and the lack of proactive mind-sets among health workers at local level (inherited from the previous political environment) are challenges that need to be overcome to make decentralization smooth and effective.

The National Health Plan remains an integral part of the comprehensive national development plan. However, there is no formal coordinated social protection mechanism to prevent families from falling into poverty as a result of the cost of health care. Only a small proportion of formal-sector workers are covered by the current formal social-security system. The government has started to take the initiative to introduce formal social protection in the country and MOH is in the process of piloting and introducing some community-based and demand-side approaches as interim measures while the Social Protection System is in the developmental stage.

There has been an increase in the number of public hospitals since the early 2000s, with an additional 140 in total. The Ayeyarwady Region has received the most, followed by Sagaing Region; however, there was no change in the number of hospitals in Chin State. Co-investment by the local community in building rural health centres and sub-rural health centres is widely practised. The number of private hospitals increased within this decade, but at a lower rate than public hospitals. Hospital equipment is usually provided by the government budget and MOH's share of government expenditure was increased four-fold in 2012. In terms of human resources for health, recruitment of doctors, nurses, and midwives have been increasing since the early 2000s, but have not yet reached the global standard of 2.28 doctor, nurse, and midwife positions per 1,000 population. There is also underproduction of dental surgeons, pharmacists, and technicians as compared to doctors and nurses.

4.3.6 Ethnic groups

Myanmar, sitting at the cross-roads of South Asia, Southeast Asia and Himalayas, is one of the most ethnically diverse countries in the world, with over 100 distinct languages and dialects (Smith, 1994). Myanmar recognises 135 separate ethnic groups, which in the Constitution are referred to as national races. The Ayeyarwady Basin is home to at least 15 ethnic groups, including the Bamar or Burmese. The Bamar is the main group comprising 65 - 70% of the total population. Although information on ethnicity collected in the 2014 census has not been publicly released, the official population estimates of the main ethnic minority groups are roughly: Shan 9%, Kayin/Karen 7%, Rakhine 4.5%, Chin 2%, Mon 2%, Kachin 1.4%, and Kayah 1% (Depatment of Water Resources and Irrigation, 2014). One of the seven ethnic states, Kachin state occupies most of Upper Ayeyarwady HEZ. Sagaing, Magway, Mandalay, Yangon, Ayeyarwady, and Bago regions are mainly Bamar dominated. There are five self-administered zones: Naga in Sagaing Region; and Danu, Pa-O, Pa Laung, and Kokang all in Shan State. The self-administered sub-national units are the result of earlier ceasefire agreements and are recognised in the 2008 Constitution. Each self-administered unit is run by a Leading Body, which has at least 10 members and includes state or region Hluttaw[11] members (ASI, 2015).

Since Myanmar's independence in 1948, many of the ethnic nationalities/indigenous peoples have fought armed struggles against the Bamar-dominated central government, initially for secession and independence, but today, in almost all cases, for autonomy, equal rights, and federal democracy within the Union of Myanmar. All of the main ethnic minority group areas have experienced various levels of conflict - including separatist rebellions - since 1962, due to perceptions of ethnic discrimination and Barma domination (see Chapter 11 for further discussion on conflict).

Armed ethnic groups have established systems of administration separate either to the government system or to the traditional systems. Most of the ethnic armed groups (EAGs) have signed ceasefire agreements with the government and the past years have seen a significant reduction in armed conflict. Sustainable development and poverty alleviation depends on a lasting peace, which must be based on a permanent mutually satisfactory agreement on control over land and resources. Up to 2015, ceasefire agreements were made with most of the EAGs and a draft nationwide ceasefire agreement was signed on 30 March 2015 (Mikkelsen, 2015; Ministry of Electric Power of Myanmar et al., 2015).

Some minority areas remain insecure and under military hold. Land grabbing conducted by the military and the state and given to state entities or to businessmen close to the regime is endemic (TAF, 2014). A strong correlation between poverty and ethno-linguistic identity ('mother tongue') was identified in the IHLCA 2010 implying that the risk of poverty is higher for non-Bamar groups as a whole.

Figure 31 shows the geographic areas that are dominantly inhabited by ethnic minority groups in the Ayeyarwady Basin. Analysing the presence of each ethnic group within each township of the basin (Table 24) reveals a correlation between hydro-ecological zone and diversity. The Upper Ayeyarwady is the most ethnically diverse followed by the Cihindwin and Middle Ayeyarady zones; while the lowland areas of the Delta and Lower Ayeyarwady Zone are the least diverse – Yangon being the exception.

Table 24 - Number of townships in hydro-ecological zones with ethnic groups

Ethnic Group	Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta	All
Assamese	1	0	0	0	0	1
Burmese	2	20	56	35	69	182
Chinese (Han)	2	0	0	0	0	2
Chini	0	9	0	15	3	27
Kachins (Singpho)	9	5	17	0	0	31
Karen	0	0	3	1	14	18
Khun	5	1	0	0	0	6
Lisu	6	1	2	0	0	9
Nagas (Ao, Sema, Lhota, Rengma, etc.)	0	5	0	0	0	5
Nua	5	0	0	0	0	5
Palaung	0	0	7	0	0	7
Shan	3	8	32	0	0	43
Tibetans (including Hsifan, Chiajung)	1	0	0	0	0	1
Wa (Kawa)	0	0	1	0	0	1
Yi (including Chila, Pupiao, Lolo)	1	0	0	0	0	1

[11] The legislative assembly in Myanmar.

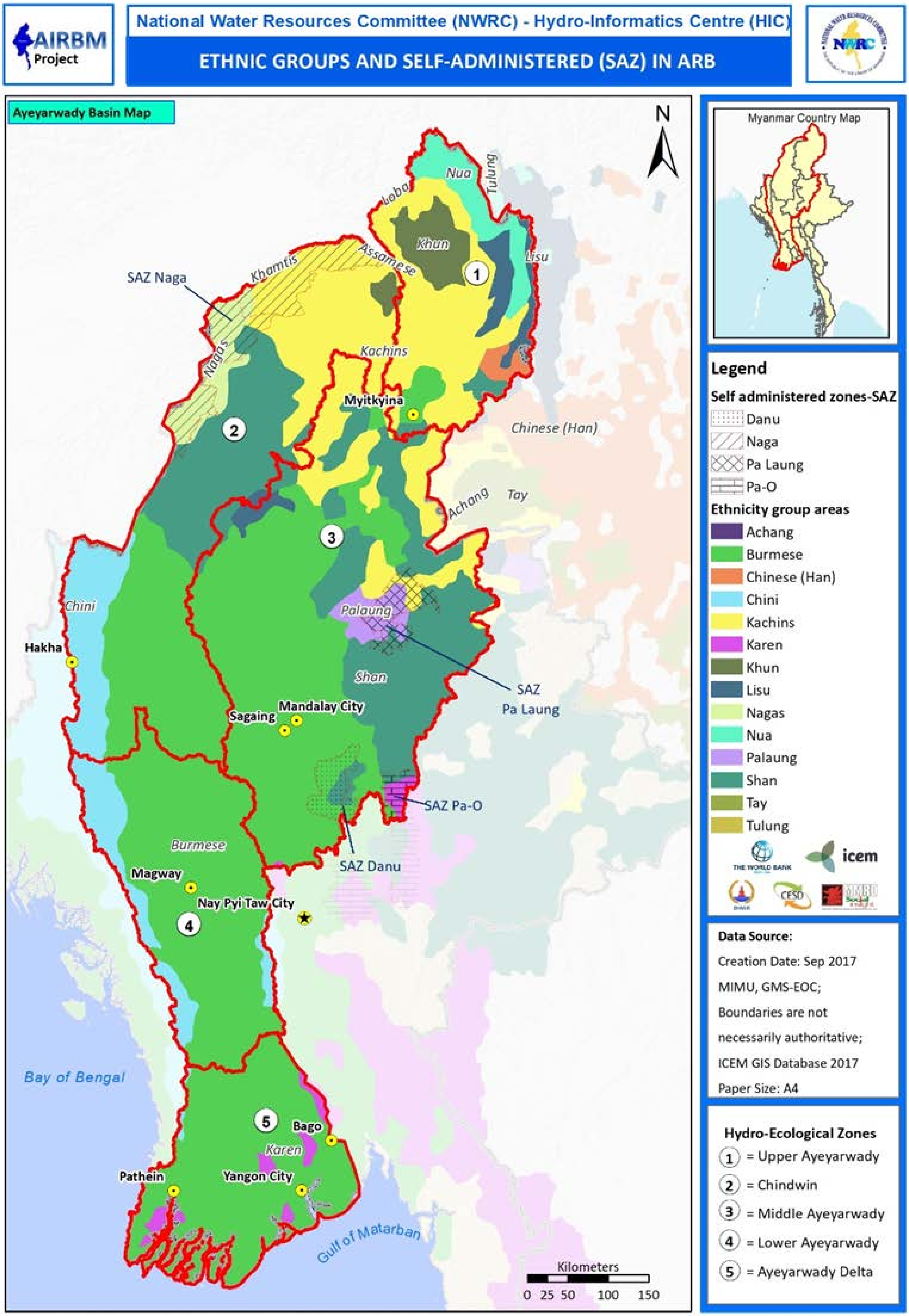


Figure 31 - Ethnic groups and self-administered zones in the Ayeyarwady Basin: *(Asian Development Bank, Greater Mekong Subregion Environmental Operations Centre map of ethnic groups)*

4.3.7 *Exposure to flooding*

Between 1970 and 2016, 12.4 million people in Myanmar were affected by floods; of this number, 11.2 million people were affected by riverine floods in 15 events. Over the period 1936 - 2016 flooding accounted for 78% of the internationally reported number of affected people from disasters in Myanmar (PreventionWeb, 2017). Most of the flood prone areas are within the Ayeyarwady Basin.

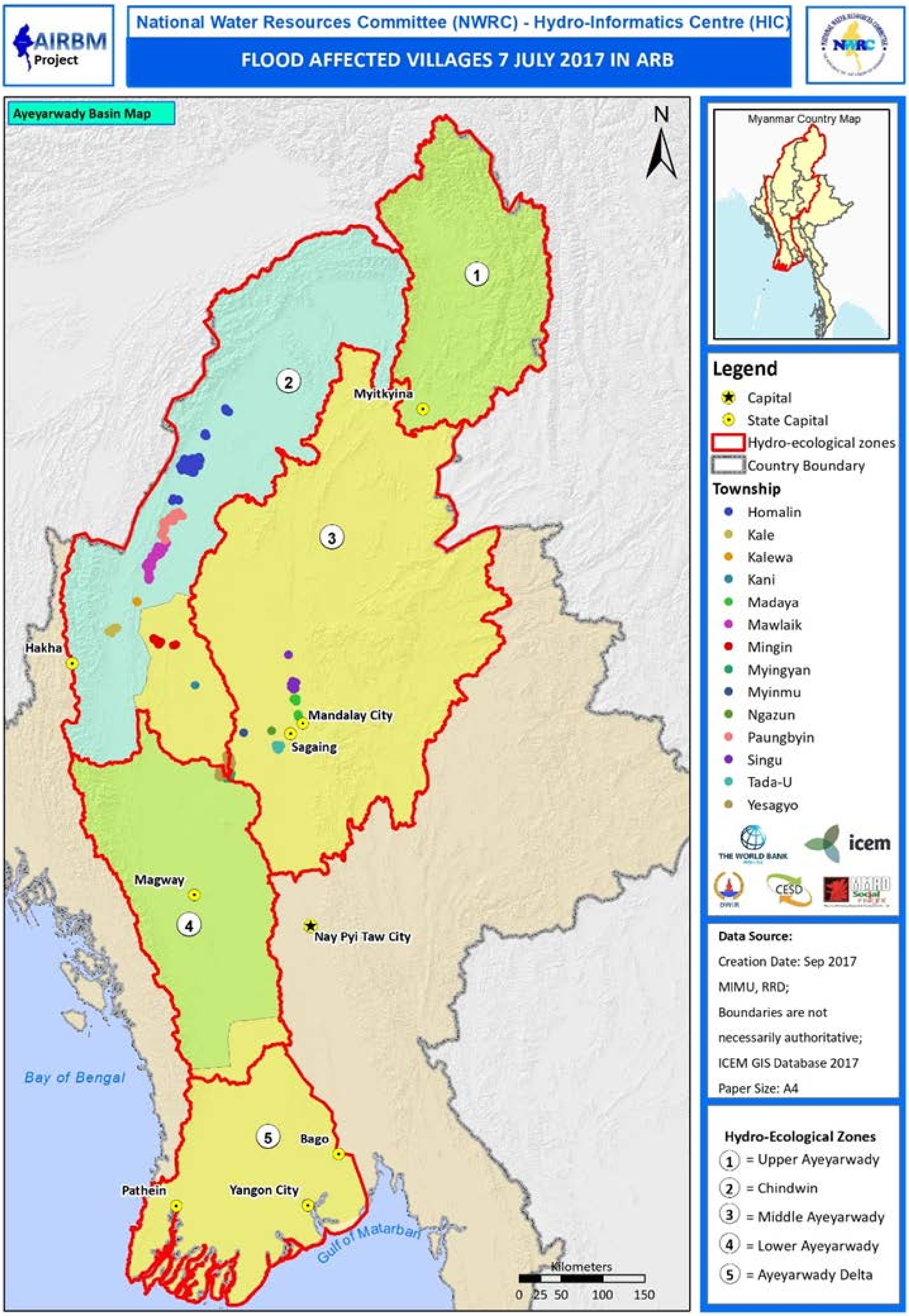


Figure 32 - Flood affected villages 7 July 2017 in the Ayeyarwady Basin

A situation picture by July 2017 is provided by the Relief and Resettlement Department, Ministry of Social Welfare, Relief and Resettlement, which lists 87 villages in 14 townships in Magway region, Mandalay region, and Sagaing region, with a total flood affected population of 134,000 people.

The World Resources Institute Aqueduct project has estimated the population in the Ayeyarwady Basin, which is likely to be affected by flooding from 5, 10, and 25 years flood return episodes. Table 25 shows the estimated population for the 2010 baseline scenario. Note that the Aqueduct data splits the Ayeyarwady Basin into Irrawaddy and Sittang River basins.

The baseline risk assessment for 5-year flood return events indicates that 2.2 million people would be affected, for 10-year flood return events 2.9 million people, and for 25-year flood return events 3.4 million people.

Table 25 - Estimated population affected by flooding in 2010 - baseline socioeconomic and hydrological scenario

(WRI, 2015)

Estimated risk in 2010	Flood return period		
	5 years	10 years	25 years
River Basin	Affected population		
Irrawaddy	1,723,342	2,321,502	2,777,283
Sittang	501,894	617,291	708,667
All	2,225,236	2,938,792	3,485,950

For a future scenario in 2030, which includes climate change scenario Representative Concentration Pathways 4.5 and socioeconomic scenario SSP2, the estimated flood affected population is shown in Table 26. The estimation is there will be an increase in flood affected population.

Table 26 - Estimated population affected by flooding in 2030 - socioeconomic change scenario SSP2, climate change scenario Representative Concentration Pathways 4.5

Projected risks in 2030 (future)	Flood return period			
	2 years	5 years	10 years	25 years
River basin	Affected population			
Irrawaddy	957,807	2,198,361	2,848,007	3,391,527
Sittang	228,725	530,671	637,325	730,657
All	1,186,533	2,729,032	3,485,332	4,122,184

Supporting these estimations, the Aqueduct analysis finds that the Delta, the Lower and Middle Ayeyarwady and the southern part of Chindwin HEZs are categorized as having high risk of flooding (Figure 33).

Figure 34 shows the population affected by floods in 2016. It is evident that the most affected are within the Ayeyarwady Basin. Greater analysis of flooding and flood impacts is provided in the technical reports in State of the Basin 1: Hydrology (SOBA 1) on hydrology and surface water, and State of the Basin 5.1 (Activity 4): Economic Valuation of Ecosystem Services in the Ayeyarwady Basin (SOBA 5.1) on ecosystem services.

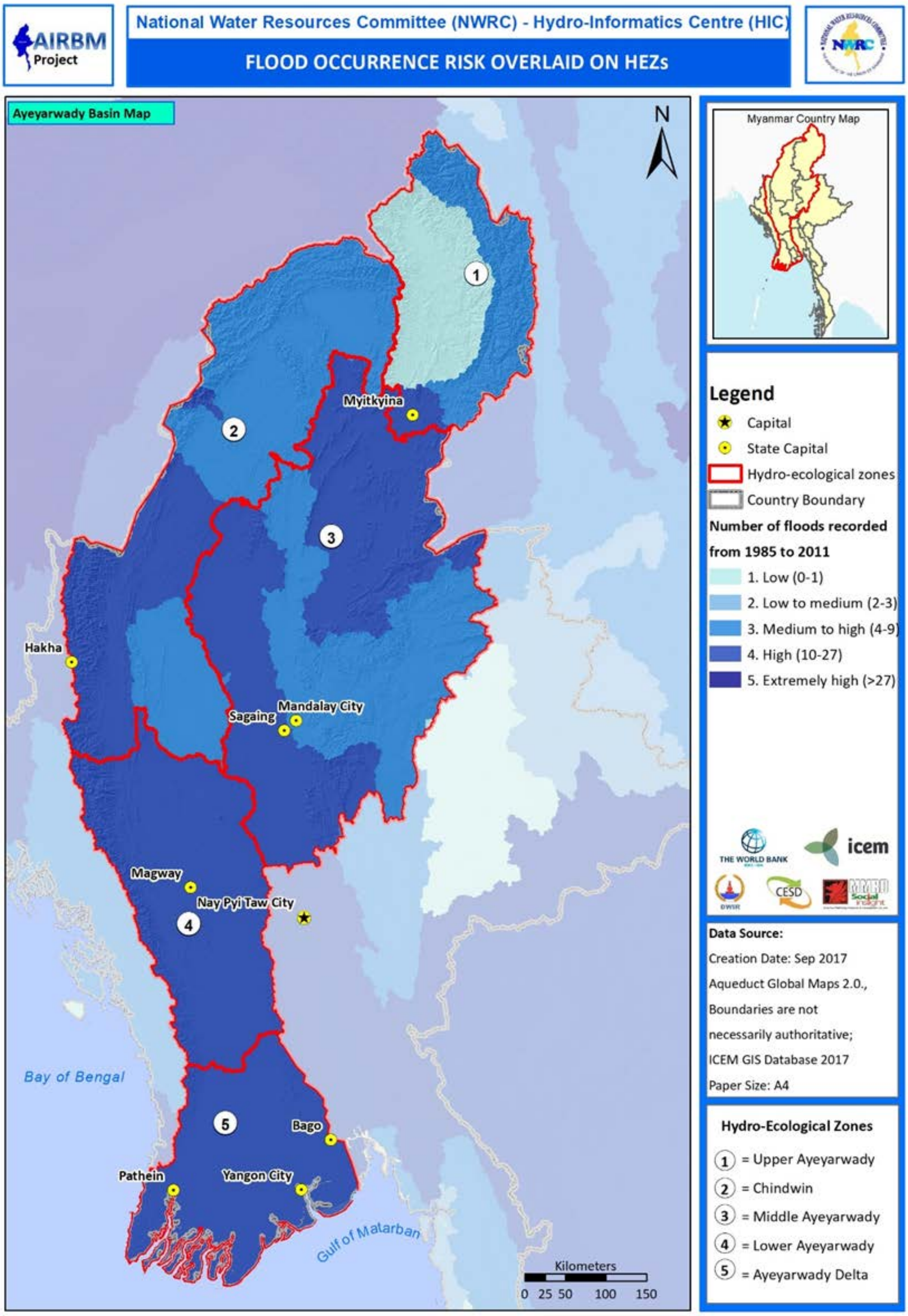
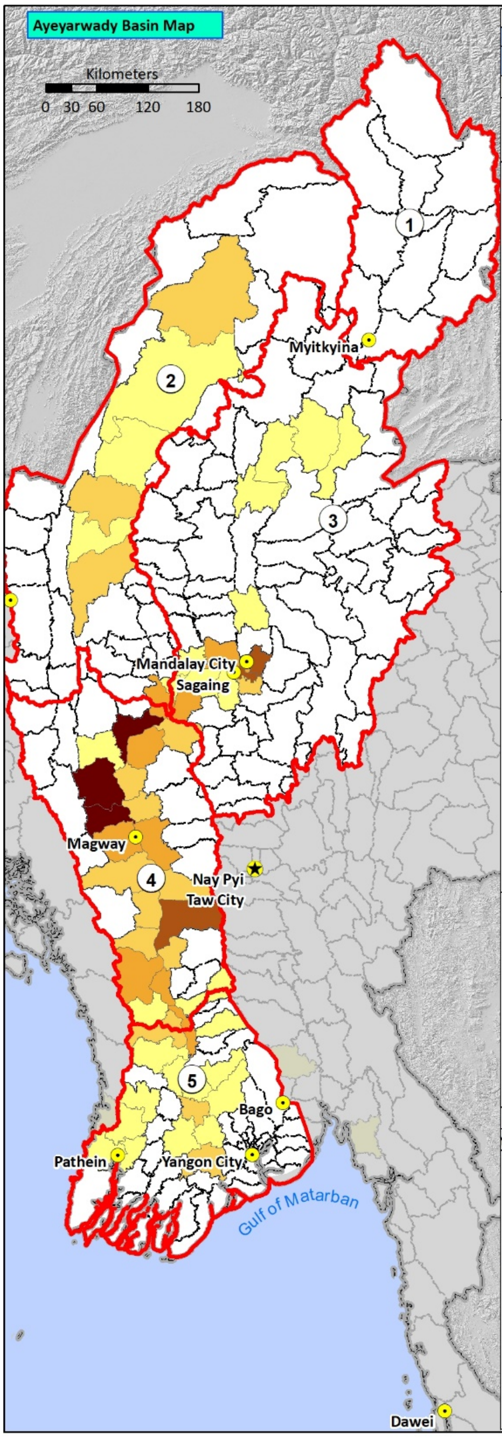


Figure 33 - Flood occurrence risk overlaid on Ayeyarwady Basin hydro-ecological zones *(WRI 2015)*

National Water Resources Committee (NWRC) - Hydro-Informatics Centre (HIC)

POPULATION AFFECTED BY FLOOD IN 2016
in the Ayeyarwady Basin, Myanmar



Statistic provided by RRD, as of 8th August 2016					
	Affected				No. of Dead
State/ Region	Township	House	HHs	Pop	
Total	62	89057	929050	377667	5
Kachin	Bhamo	145	145	704	
	Momauk				1
	Shwegu	24	24	107	1
Sagaing	Hkamti	732	748	3740	
	Homalin	155	155	835	
	Kalewa	289	296	1482	
	Katha	296	296	1415	
	Mawlaik	701	701	3430	
	Mingin	685	685	3418	
	Myaung	623	623	1330	
	Myinmu	630	630	2722	
	Paungbyin	204	204	1110	
	Sagaing	1816	1821	7508	
	Salingyi				1
	Tigyaing	131	131	585	1
Bago	Daik-U	177	177	748	
	Monyo	3499	3499	12293	
	Nattalin	269	269	964	
	Okpho	191	191	750	
	Padaung	2804	2804	10253	
	Pyay	1533	1533	6099	
	Shwedaung	2087	2087	7772	
	Thayarwady	137	137	431	
Magway	Aunglan	3156	3254	13439	
	Chauk	1905	2119	7211	
	Kamma	1725	1763	6779	
	Magway	2548	2653	10615	
	Minbu	2691	2804	10442	
	Minhla	1074	1088	4243	
	Pakokku	9655	10801	49252	
	Pwintbyu	5260	5880	26802	
	Salin	11609	12016	48672	
	Seikphyu	604	606	2276	
	Sinbaungwe	771	786	3204	
	Thayet	1308	1308	4938	
	Yenanggyaur	1486	1666	4895	
	Yesagyo	2487	2660	11388	
Mandalay	Amarapura	3243	3367	13363	
	Myingyan	2783	2869	10734	
	Ngazun	104	104	384	
	Nyaung-U	2144	2323	9471	
	Patheingyi	4892	4892	23405	
	Pyigyitagon	1473	1651	6683	
	Singu	45	45	197	
	Sintgaing	1196	1271	5292	
	Tada-U	344	344	1365	
	Taungtha	1452	1530	6681	
Mon	Thaton	40	40	185	1
Yangor	Taikkyi	515	515	1806	
Ayeyarwady	Danubyu	2309	2309	6871	
	Hinthada	381	381	1326	
	Ingapu	92	92	316	
	Kangyidaun	22	23	83	
	Kyangin	583	583	1852	
	Maubin	1513	1501	6118	
	Myanaung	1322	1322	4916	
	Nyaungdon	274	261	1198	
	Pantanaw	183	183	752	
	Pathein	210	210	565	
	Thabaung	228	228	938	
	Yegyi	36	36	154	
	Zalun	266	226	1070	

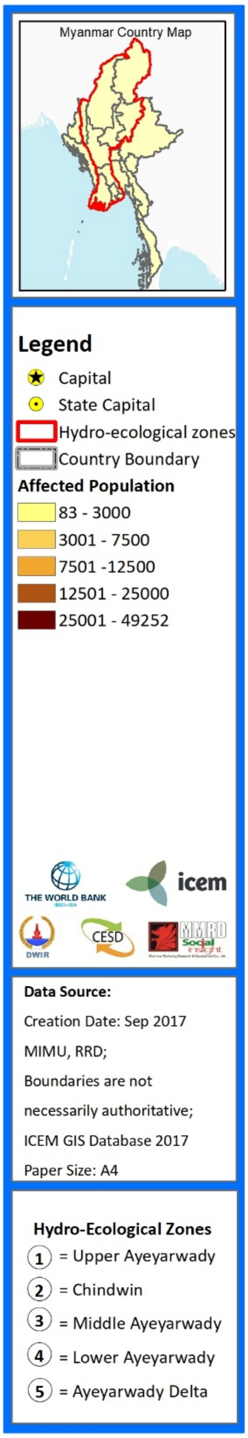


Figure 34 - Population affected by floods 2016, Relief and Resettlement Department information *(MIMU)*

4.3.8 Child health and nutritional status

Important indicators of socioeconomic development, quality of life, and quality of health care services are infant and child mortality. Infant mortality is the probability of dying between birth and the first birthday, while child mortality is the probability of dying between the first and fifth birthday. Under-five mortality is the probability of dying between birth and the fifth birthday.

The mortality rates are defined as deaths per 1,000 live births. The *Myanmar Demographic and Health Survey 2015-16* was sample based and valid for statistical results by state/region. The data on child and infant mortality for the state/regions that cover the Ayeyarwady Basin show that under-five mortality was highest in Chin State, at 104 deaths per 1,000 live births, while infant mortality was highest in Bago Region at 80 deaths per 1,000 live births. According to the Demographic and Health Survey, the variations between state/regions are likely due to differences in accessibility to health care and sociocultural contexts. The data does not allow for analysis of infant and child mortality for the Ayeyarwady Basin or by HEZ.

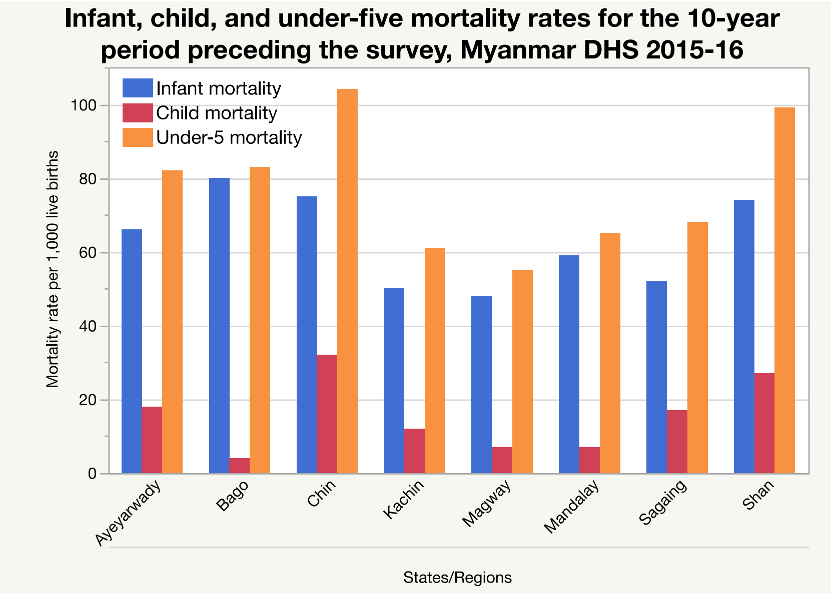


Figure 35 - Infant, child, and under-five mortality rates: *Data for Yangon not compatible with other data therefore excluded.*

The nutritional status of children is another important indicator for socioeconomic development and is a proxy indicator for food security. Stunting, or low height-for-age, is a sign of chronic undernutrition that reflects failure to receive adequate nutrition over a long period. Wasting, or low weight-for-height, is a measure of acute undernutrition and represents the failure to receive adequate nutrition in the period immediately before the survey. Wasting may result from inadequate food intake or from a recent episode of illness causing weight loss. Underweight (and overweight) is based on weight-for-age and is a composite index of weight-for-height and height-for-age. Thus, it includes both acute (wasting) and chronic (stunting) undernutrition and is an indicator of overall undernutrition.

According to the survey, in the state/regions covering the Ayeyarwady Basin, 29% of children under age five were stunted and 8% are severely stunted, indicating chronic undernourishment. Seventeen percent of children under age five were underweight, and 3% severely underweight. Six percent were wasted and 1% severely wasted, indicating acute undernutrition. Only less than 1% of children under age five were overweight. These percentages were in line with the Union level percentages. According to the survey report, the figures implied that there had been some improvement in child undernutrition. The results of the 2009-10 Multiple Indicators Cluster Survey showed that 35% of children under age five in Myanmar were stunted. Similarly, 8% were wasted and 23% were underweight.

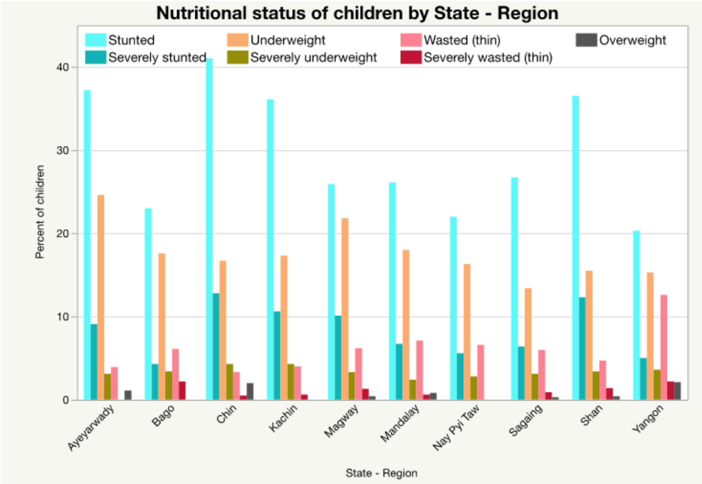


Figure 36 - Nutritional status of children by state/region *(Myanmar Demographic and Health Survey 2015 - 2016)*

4.4 Occupations and Socioeconomics

For an analysis of occupations and socioeconomics in the context of the river basin report it would be relevant to include variables for poverty rate, ownership to land and livestock, household income and expenditure, as well as income from water resource related activities. However, data for these variables are not available. This section presents the available data on labour force by sector, households' primary and secondary occupations, households' ownership to means of transportation and production, and results from a baseline survey carried out by the LIFT programme in 2012.

The Ayeyarwady Basin has 66% of the total workforce in Myanmar. In the 2014 census, the data on the 'usual activities' of people are grouped into a number of categories of which the largest is 'own account worker' (which would be similar to 'self-employed') (UNFPA 2014). The category includes independent, self-employed people (farmers, fishers, handicrafts, etc.), which are assumed to be more dependent on natural resources for their livelihood. The percentage of 'own account worker' is approximately 24 - 26% in all HEZs, except in the Delta where only 16% of economically active people are 'own account workers'. This reflects the high percentage (24%) that are private employees in the Delta HEZ (see Figure 37 and Table 27).

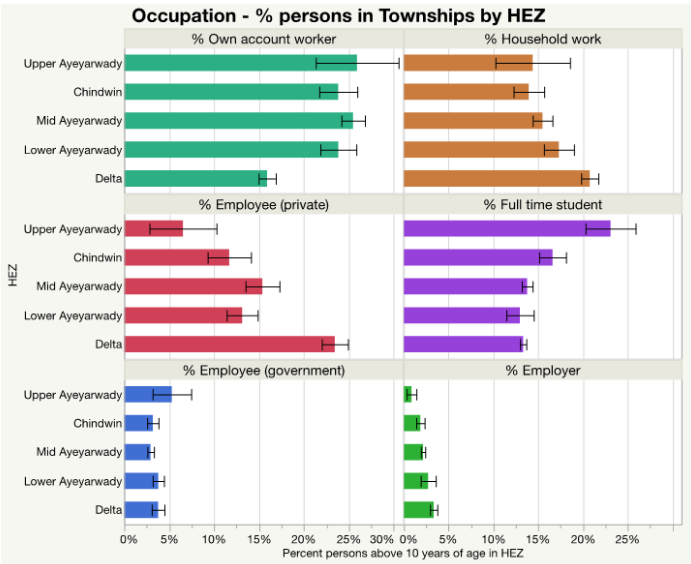


Figure 37 - Usual activities of persons, mean % of townships by hydro-ecological zone, each error bar is constructed using a 95% confidence interval of the mean: *Pensioners, disabled, unpaid family workers, job seekers, and other work not shown (UNFPA 2014)*

Table 27 - Mean % of persons in townships by usual economic activity by hydro-ecological zone *(UNFPA 2014)*

Ayeyarwady Basin HEZ	% Own account worker	% Employee (private)	% Employee (government)	% Employer	% Full time student	% Household work	% Unpaid family worker	% Pensioner, retired	% Ill, disabled	% Sought work	% Did not seek work	% Other work
Upper Ayeyarwady	25.9%	6.5%	5.3%	0.8%	23.1%	14.4%	14.9%	3.5%	0.8%	2.7%	0.4%	1.6%
Chindwin	23.8%	11.7%	3.2%	1.8%	16.6%	13.9%	18.0%	5.5%	0.8%	2.2%	0.3%	2.0%
Middle Ayeyarwady	25.5%	15.4%	2.9%	2.1%	13.8%	15.5%	13.2%	6.0%	0.7%	2.0%	0.3%	2.8%
Lower Ayeyarwady	23.8%	13.1%	3.8%	2.7%	13.0%	17.3%	13.2%	6.6%	0.8%	2.0%	0.2%	3.4%
Delta	15.9%	23.4%	3.8%	3.3%	13.3%	20.8%	5.0%	6.2%	0.8%	2.4%	0.4%	4.7%
All	21.8%	16.8%	3.5%	2.5%	14.3%	17.3%	11.2%	6.0%	0.8%	2.2%	0.3%	3.4%

a) Occupations by industry

The census includes more detailed data on persons employed in various industries, however the data are aggregated at state/region level and can only be presented here as such for the state/regions that are part of the Ayeyarwady Basin (Figure 38). Furthermore, the data seems to under-represent the population in mining, which is indicated as 300,000 seasonal jade pickers in Hkpant, up to a similar number in Mogok and 100,000 in Magway region (Section 7) involved in small scale oil extraction. Agriculture, forestry, and fishing employ by far the largest proportion of people in all state/regions, except in Yangon. The available census data aggregates agriculture, forestry, and fishing into one category, which makes it impossible to separate livelihoods that are mainly dependent on river and other surface water resources. People employed in manufacturing are mainly in Yangon and Mandalay.

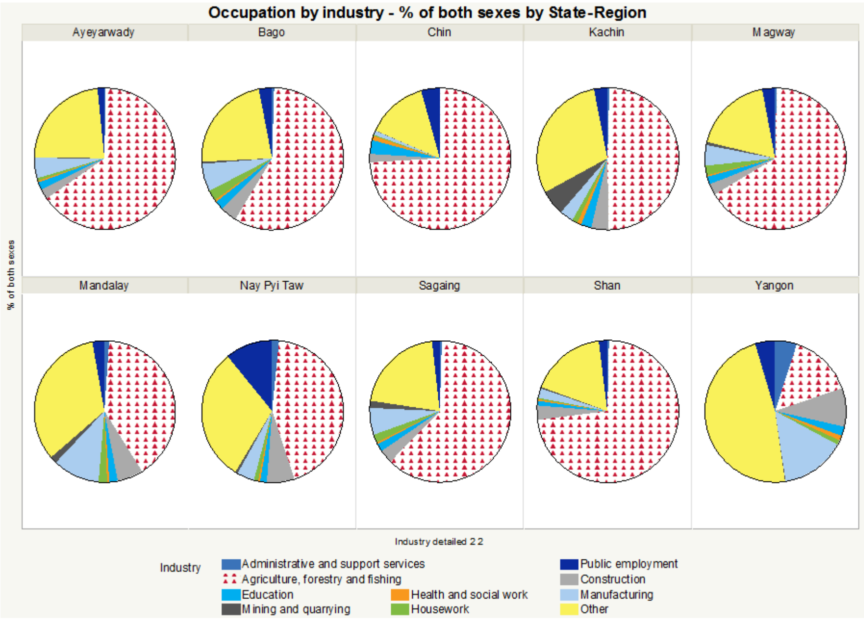


Figure 38 - Occupation by industry, percentage of both sexes by state/region: *A number of industries with few people have been grouped into 'Other' (UNFPA 2015).*

4.4.1 Households' sources of income (from LIFT Baseline Survey, 2012)

In the absence of updated and detailed socioeconomic data on income sources in the Ayeyarwady Basin, we refer to a Baseline Survey from 2012. LIFT is a multi-donor fund designed to increase food availability and incomes of two million target beneficiaries: the poor and vulnerable. LIFT works through a trust fund modality providing funding to a broad array of implementing partners including international NGOs, national NGOs and private sector agencies, and United Nations organisations.

The LIFT Baseline Survey aimed to provide representative quantitative and qualitative information on livelihoods and food security covering villages proposed by LIFT partners working in the Delta II and countrywide sub-programmes, and comparable control villages. Baseline information was required to represent and allow statistical comparisons among the three agro-ecological zones (Coastal/Delta, Hilly and Dry zones). The survey covered a total of 252 villages chosen with probability proportional to their number of households. Eight-hundred households were randomly selected from each zone (Coastal/Delta, Hilly, and Dry zone). In addition, a number of villages in Rakhine State, and a number of control villages were surveyed. As such the LIFT Baseline Survey covers a significant part of the Ayeyarwady Basin (Figure 39).

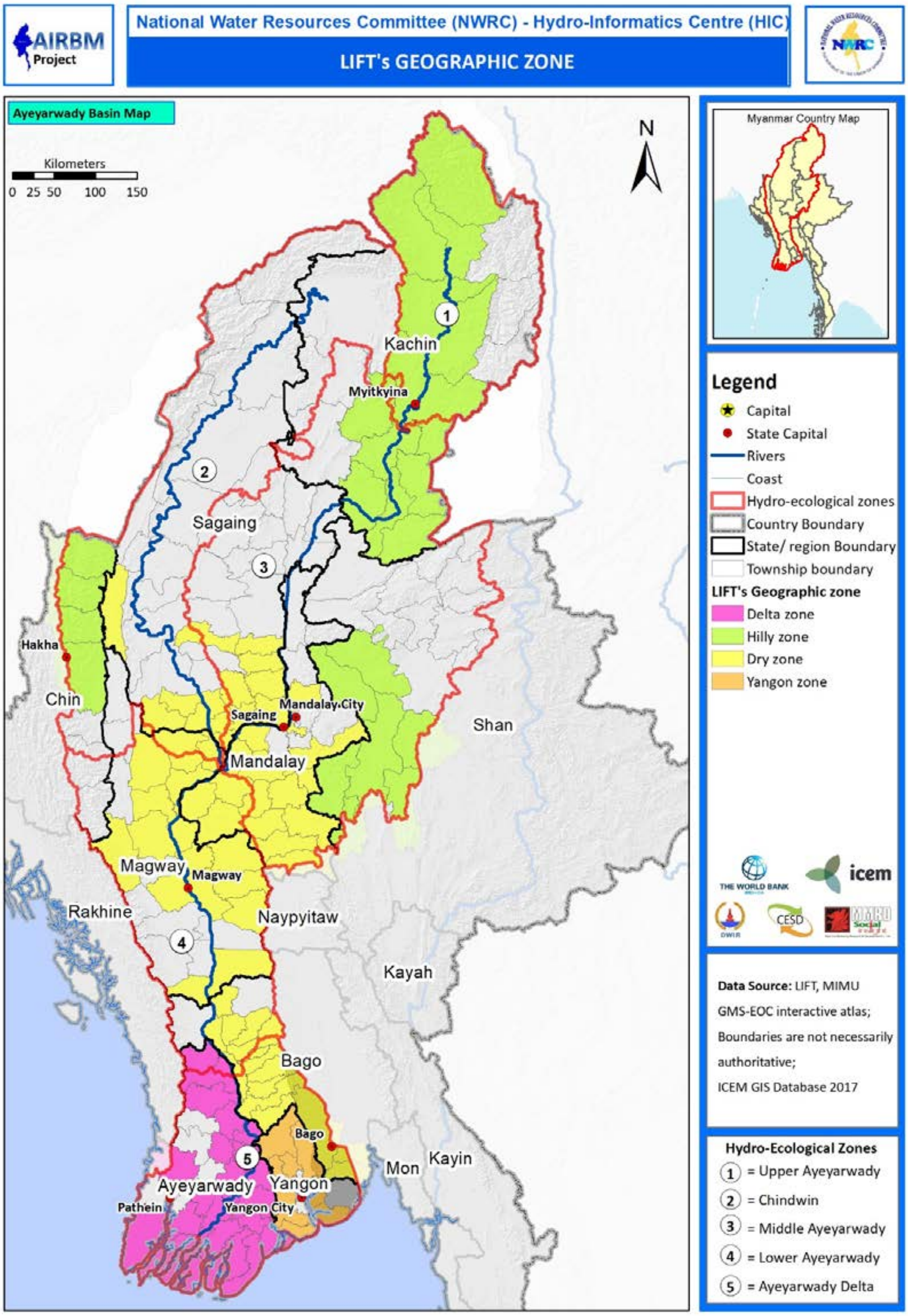


Figure 39 - LIFT Geographic zones

The survey confirmed that agriculture and related activities, including casual labour in agriculture, are by far the most important economic activities for most households in the survey area (Figure 40, details Figure 41).

Casual labour in agriculture was the most common source of income of households in the Dry Zone and in the Delta, and together with sale of other cereals, also the most important source of income in the Hilly Zone. Agriculture, i.e., sale of beans, pulses, peanuts, other cereals, paddy rice, and vegetables was the second most important source of income in all zones. Fisheries and related activities were important sources of income for many households in the Delta.

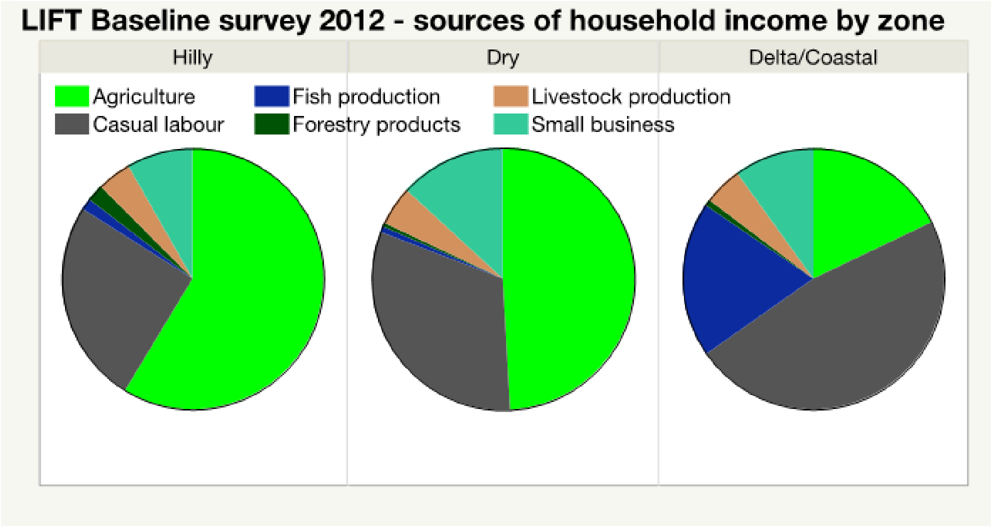


Figure 40 - Household income sources by Hilly, Dry, and Delta zones *(LIFT Baseline Survey, 2012)*

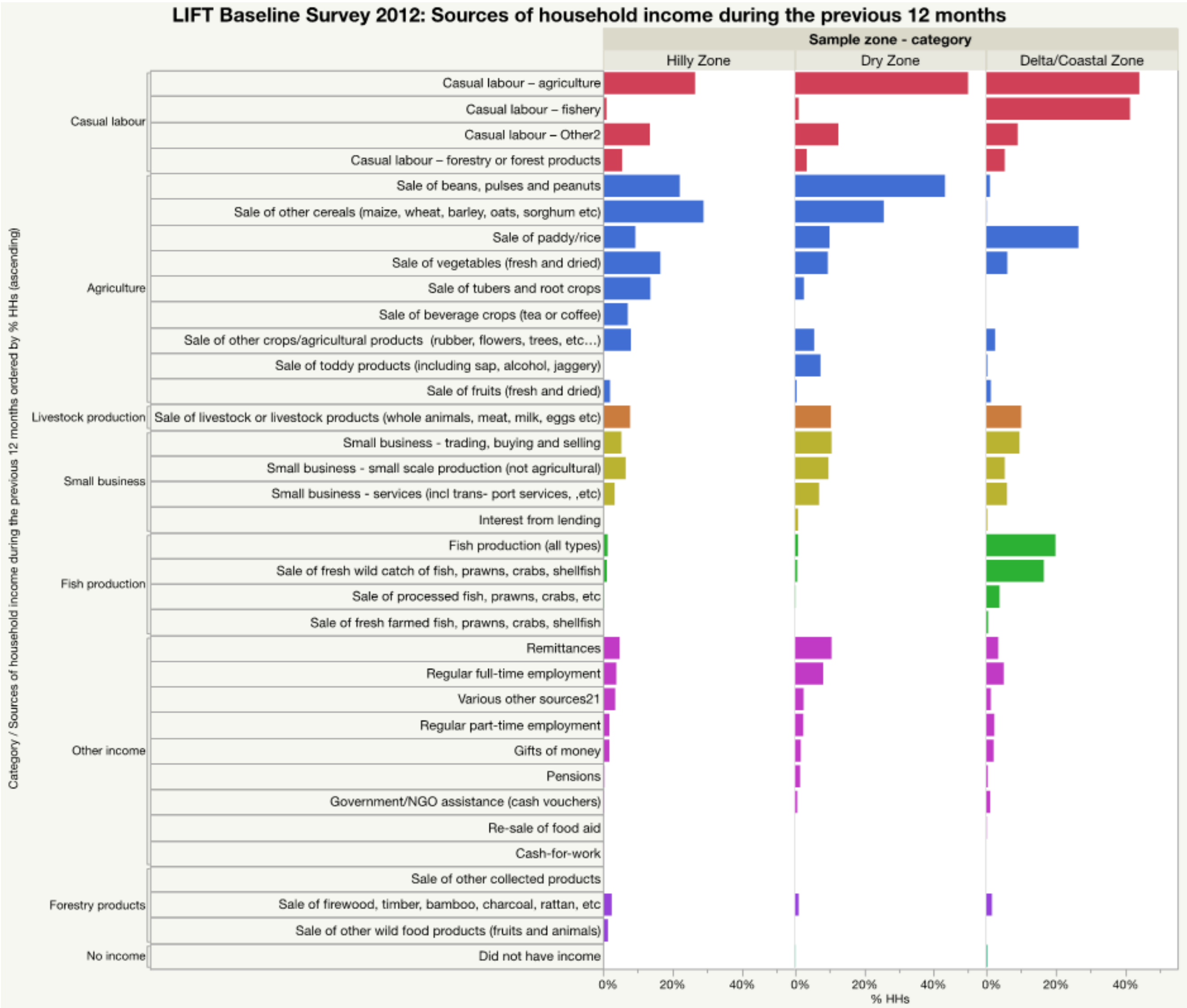


Figure 41 - Sources of household income *(LIFT Baseline Survey, 2012)*

Note: Multiple responses were allowed

4.4.2 Landownership

The data source for ownership to land is also the LIFT Baseline Survey. Fifty percent of the total sample households did not own land. However, there was considerable variation in land ownership between the zones. In the Delta, 72% of the household did not have land, 43% in the Dry Zone and 26% in the Hilly Zone (Figure 42). Households gained access to land for agriculture through paying rent in cash or agricultural product, sharing farmed land belonging to other households, or by being lent land to cultivate, often from relatives. An in-depth discussion of access to land is included in Chapter 11.

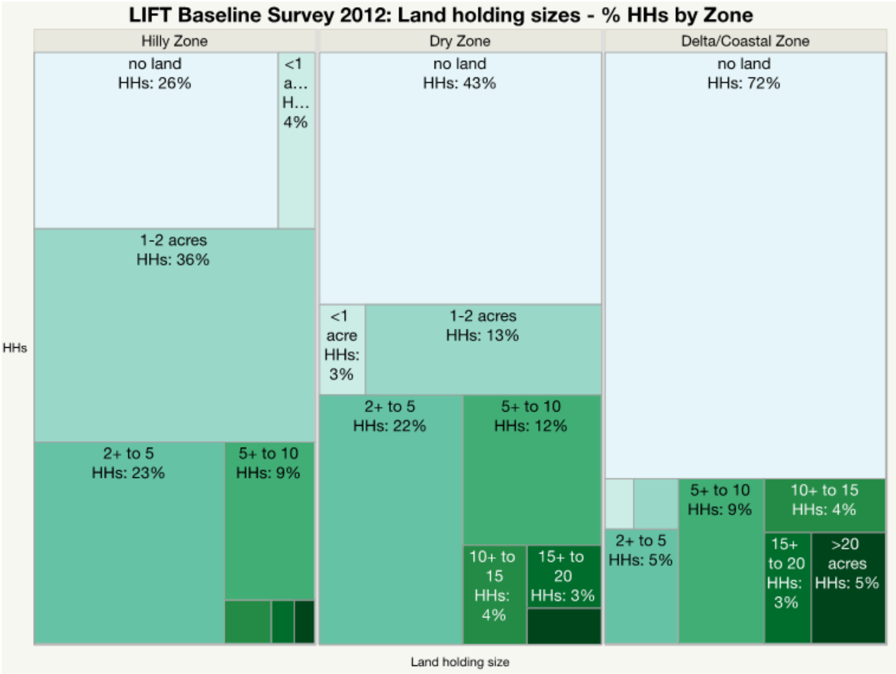


Figure 42 - Land ownership and holding sizes by Zone *(LIFT Baseline Survey, 2012)*

Land ownership was skewed especially in the Delta, with both a large proportion of landless households, and households which owned an average of 16.8 acres, and a further 5% of households that owned more than 20 acres (Table 28).

Table 28 - Average size of land holdings in acres for those households that owned land, LIFT Baseline Survey (2012) *(LIFT Baseline Survey, 2012)*

	Mean	Median	Minimum	Maximum	Standard deviation
Hilly Zone	3.51	2	0.25	100	5.29
Dry Zone	6.32	4.5	0.1	60	6.47
Delta and Coastal Zone	16.81	10	0.25	180	24.48

4.4.3 Ownership of means of transportation

Households' ownership to means of transportation, which can be considered productive assets, is an indicator of their socioeconomic status. This section presents an analysis of Census 2014 township data broken down by means of transportation and aggregated for the Ayeyarwady Basin and by HEZs. Bicycles, bullock carts, and motorcycles/mopeds are the most common means of transport in the Ayeyarwady Basin. Only 4.2% of households own a car or truck (Figure 43; Table 29). Ownership of boats is most common in the Delta, along the Chindwin and in the Middle Ayeyarwady HEZ. Apart from the abundance of waterways in the Delta, ownership to boats also reflects the lack of road transportation infrastructure.

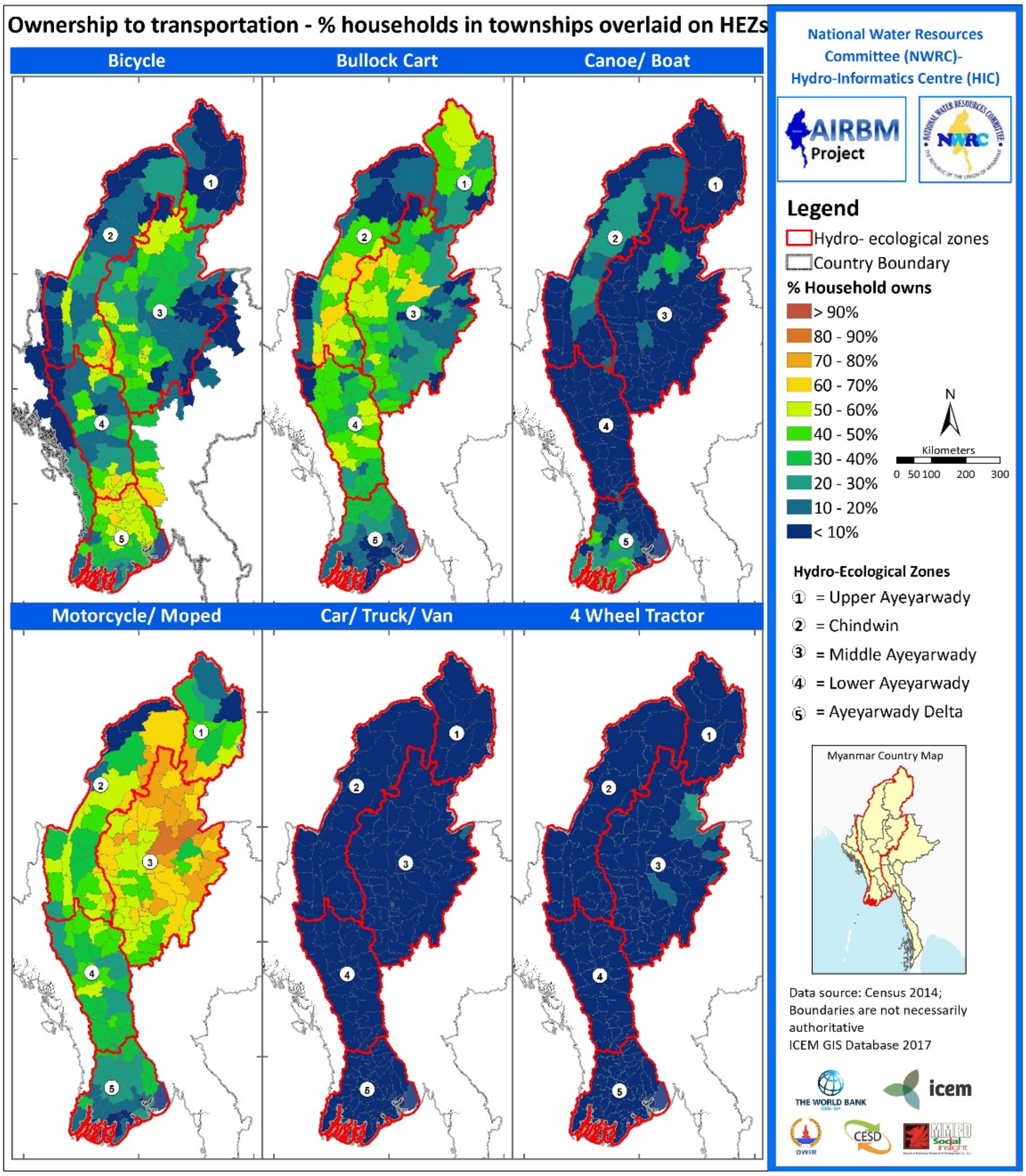


Figure 43 - Ownership of means of transportation, % households in townships overlaid on hydro-ecological zone *(UNFPA 2014)*

Table 29 - Ownership of means of transportation, mean % of households that own by hydro-ecological zone *(UNFPA 2014)*

Means of transportation	Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta	Entire Ayeyarwady Basin
	Mean of township % HHS who owns					
Bicycle	6.8%	28.2%	34.1%	30.5%	38.5%	33.0%
Bullock cart	37.5%	34.2%	31.2%	37.8%	9.8%	25.9%
Canoe/boat	0.7%	4.0%	2.4%	1.6%	6.1%	3.7%
Motorcycle/moped	36.7%	45.4%	62.3%	36.1%	13.4%	38.2%
Car/truck/van	1.4%	1.3%	3.5%	1.2%	8.0%	4.2%
Four-wheel tractor	1.1%	1.2%	3.6%	0.8%	1.4%	2.0%
Motor Boat	0.5%	2.2%	1.1%	0.5%	2.8%	1.7%

4.4.4 Fisheries

Inland fisheries in Myanmar are extremely important, also compared to other countries in the region. A 2012 report placed Myanmar as the top Southeast Asian producer from inland fisheries, with a production volume almost twice that of the next largest, Indonesia (SEAFDEC, 2012).

The inland fisheries are mostly rural and artisanal; they are 'small-scale, multi-species, multi-gears, involving large number of fishers which are mostly part-time fishers, while the major parts of the fishery production are meant for household consumption' (SEAFDEC, 2012). Therefore, statistics on involvement and production are difficult to obtain. There are no disaggregated data available that would allow an analysis of the extent of fisheries in the Ayeyarwady Basin or the HEZs.

The Department of Fisheries assess that approximately 1.6 million people are involved in freshwater capture fisheries, with approximately half a million people full-time engaged and approximately one million people part-time engaged (MLFDR, 2015). There appears to be no significant change in those numbers over the last years up to 2013, but accelerating development of aquaculture in the Ayeyarwady Delta is reported. A much more detailed survey of capture fisheries and aquaculture and their role in livelihoods in the Ayeyarwady Basin has been conducted as part of the State of the Basin 4: Fisheries, Aquaculture and Fishers Consultations.

4.5 Trends in Rural Livelihoods

The absence of quantitative and comprehensive time series data on occupation and employment structure makes it difficult to elicit trends in rural livelihoods in the Ayeyarwady Basin. For a qualitative assessment, the *Livelihoods and Social Change in Rural Myanmar* social and economic monitoring of a panel of 54 villages in Ayeyarwady region, Chin state, Magway region, Mandalay region, Rakhine region, and Shan state provides probably the most comprehensive information. In 2016 it was reported that over the period from 2012 to 2015 some areas had experienced improvement, while some remained vulnerable. Wages had increased but peak season labour scarcity remained a challenge. Notably, villages had greater access to low interest loans. The position of subsistence and small-scale fishermen was declining; however, the reason for this is not clear. Due to the Ward and Village Tract Administration Law, Village Tract Administrators experienced increased levels of authority, while the influence of village administrators declined. People had higher expectations of government, including in delivering government services, and were more willing to express discontent when their expectations were not met. Overall, the results of the monitoring between 2012 and 2015 presented a mixed picture of the trends in rural livelihoods.

4.6 Access to Services

Access to public services is important for the resilience and development potential of rural communities and families. This section present analyses of the situation in the Ayeyarwady Basin with regard to road access in rural areas, sources of lighting and access to electricity for lighting and cooking, and access to different types of drinking water and non-drinking water sources and sanitation facilities.

4.6.1 Road access

It has been estimated that 20 million people in Myanmar live in villages without access to an all-season road. The Union has approximately 64,000 villages and only 75,000 km of all-season roads, which is just above 1 km of road per village. This is far below what would be needed to achieve universal access (ADB, 2016). In 2016, the ADB calculated for Myanmar’s states and regions the Rural Access Index (RAI), an international indicator developed by the World Bank, which is defined as the percentage of the rural population that is within 2 km of an all-season road. The RAI is generally over 90% in high-income countries and drops to less than 20% in a small number of poor countries in Africa and Asia. To calculate the RAI, it was assumed that all the people in villages not connected by all-season roads are further than 2 km from an all-season road. It was also assumed that where there is an all-season road, some of the population will live more than 2 km from that road (a proportion estimated from data on road lengths and population densities). The RAI for the state/regions that cover the Ayeyarwady Basin are presented in Table 30.

Table 30 - RAI for state/regions covering the Ayeyarwady Basin

State/region	Villages without road			Villages with dry-season road			RAI %
	Villages	Population	Required improvement (km)	Villages	Population	Required improvement (km)	
Ayeyarwady	6,334	2,225,603	12,498	2,940	1,501,878	5,802	24
Bago	1,947	749,996	5,430	2,383	1,330,581	6,646	37
Chin	251	47,086	1,807	907	261,180	6,529	11
Kachin	1,304	427,326	8,754	734	352,797	4,926	18
Magwe	0	0	0	2,964	1,684,227	10,421	39
Mandalay	422	235,841	1,344	1,792	1,174,815	5,706	61
Sagaing	1,146	561,243	5,018	3,041	2,069,759	13,316	28
Shan	8,228	2,041,539	39,206	2,719	977,991	12,957	23
Yangon	125	86,005	288	964	794,891	2,221	60
Myanmar	*24,765*	*9,205,092*	*99,200*	*19,868*	*11,306,596*	*75,785*	36

The RAI for the state/regions ranges from a low of 11% in Chin state to a high of 61% in Mandalay region. Kachin state has a RAI of 18% and Shan state, Ayeyarwady region, and Sagaing region all have RAIs below 30%.

4.6.2 Source of lighting

The Census 2014 included questions about the sources of lighting that households use. An overall comparison of the mean value for townships in the Ayeyarwady Basin and those outside the Ayeyarwady Basin shows no statistically significant difference, but there are some noteworthy differences: access to grid electricity is on average higher in Ayeyarwady Basin townships (mean of 34% of households) compared to townships outside of the Ayeyarwady Basin (26%). Use of battery is at a mean of 18% of households in Ayeyarwady Basin townships, but only 7% outside of the Ayeyarwady Basin. Candles are more common in townships outside of the Ayeyarwady Basin, at a mean 29% of township households, compared to 19% in the Ayeyarwady Basin. The following is an analysis of sources of lighting by HEZs. While the mean percentage of households in Ayeyarwady Basin townships using candles is 19%, in the Upper Ayeyarwady as many as 47% of households use candles (Figure 44).

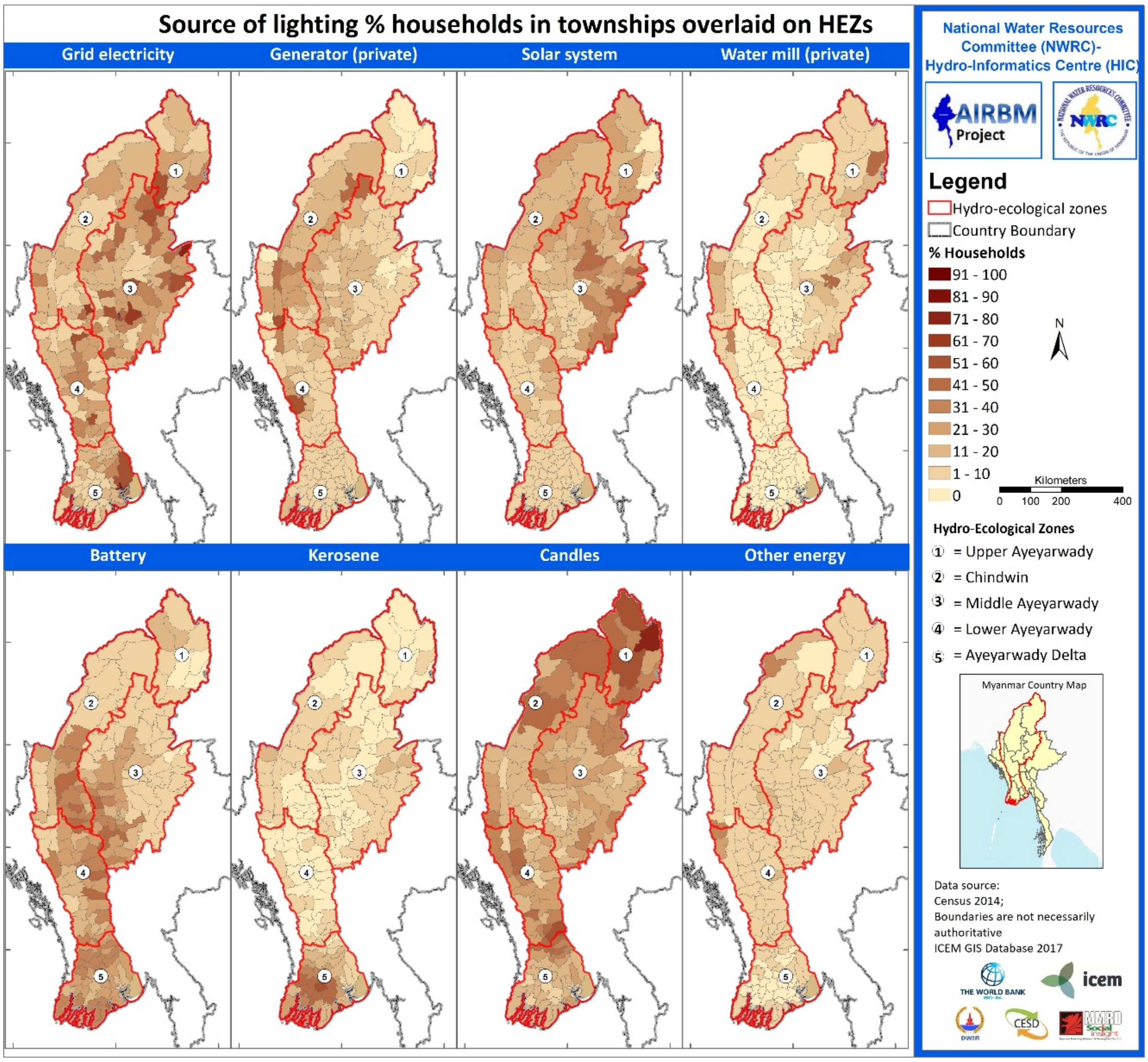


Figure 44 - Source of lighting % households in townships overlaid on hydro-ecological zone *(UNFPA 2014)*

Batteries are commonly used, especially in the Chindwin and Lower Ayeyarwady in 21 - 23% of households. Solar systems are also common in 11% of households in the Ayeyarwady Basin. Grid electricity for lighting is used by a mean of 34% of households in townships, with the highest mean in the Delta at 52%. However, the Delta includes Yangon, which raises the percentage significantly.

With regard to access to grid electricity for lighting and cooking, Figure 44 shows the quantiles of township percentages of households by state/region grouped by HEZ. The percentage of households with access ranges from a low of 17% in the Upper Ayeyarwady and Chindwin to 52% of households in the Delta. However, the urban areas of Yangon have much higher percentages of households with access to grid electricity, which distorts the picture in other parts of the Delta HEZ, where access is much lower. The issue of household access to electricity and energy use is discussed in greater detail in Chapter 8 on energy.

4.6.3 Access to drinking water and sanitation

The most common drinking water source in the Ayeyarwady Basin are tubewell boreholes, which provide water for approximately 33% of households. Water from protected springs is the second most common source at 17% of households, and bottled or purified water is the third most common source at 11% of households. Waterfalls and rainwater provide drinking water for as much as 42% of households in the Upper Ayeyarwady, while pools, ponds, and lakes are the water source for 17% of households in the Delta. Drinking water from rivers, streams, and canals is also quite widespread, with 14% of households in the Upper and Lower Ayeyarwady using these sources for drinking water (Figure 44; Table 31).

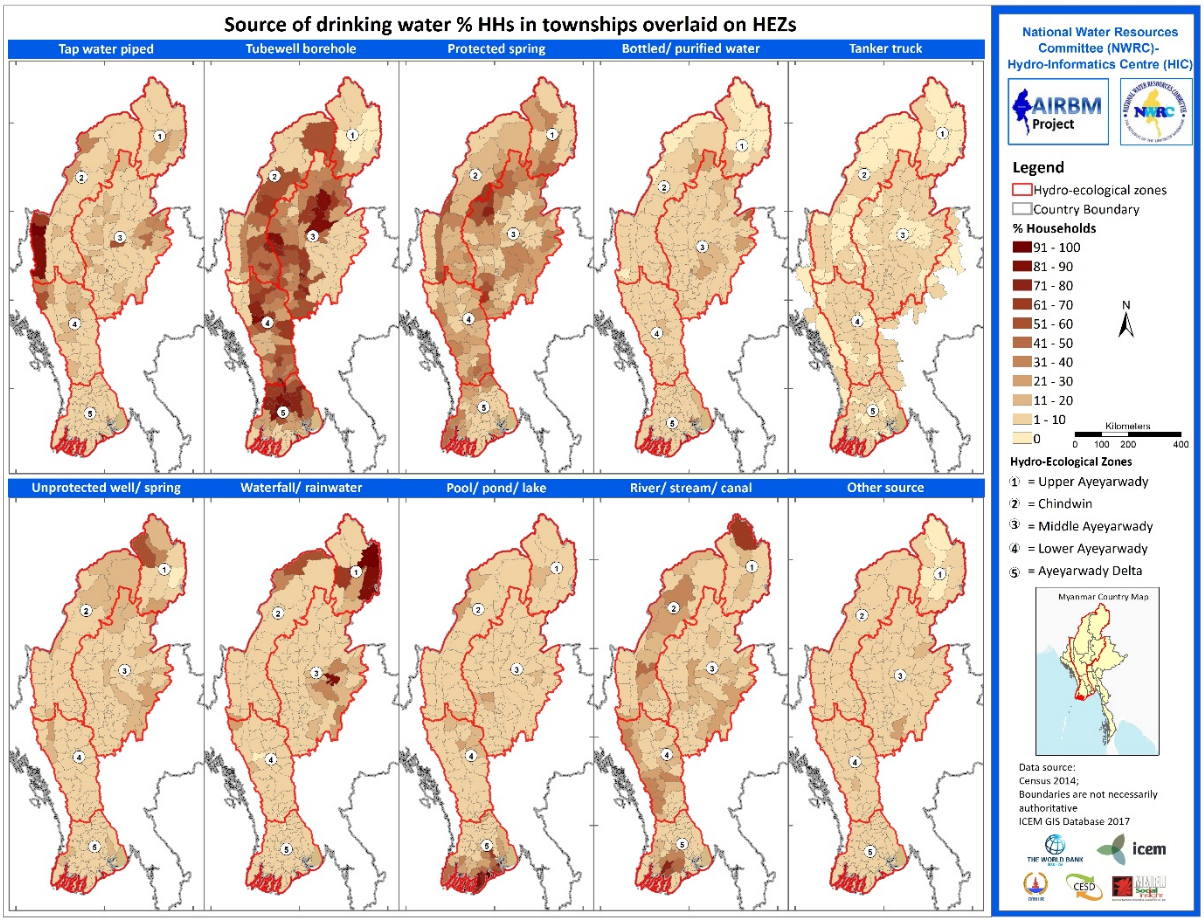


Figure 45 - Source of drinking water % HHs in townships overlaid on hydro-ecological zone *(UNFPA 2014)*

Table 31 - Source of drinking water mean % HHs in townships in hydro-ecological zones *(UNFPA 2014)*

	Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta	All
Source of drinking water	**Mean % HHs in townships**					
Tap water piped	7.4%	19.3%	10.4%	9.0%	10.0%	11.1%
Tube well borehole	2.3%	30.5%	38.5%	42.7%	29.2%	33.4%
Protected spring	16.4%	22.7%	21.6%	19.2%	7.7%	16.5%
Bottled/purified water	0.4%	1.3%	6.8%	1.7%	26.3%	11.4%
Tanker truck	0.0%	0.1%	0.5%	0.4%	0.3%	0.3%
Unprotected well/spring	16.1%	5.3%	4.6%	3.6%	1.6%	4.0%
Waterfall/rainwater	42.2%	4.9%	5.2%	2.2%	0.6%	4.7%
Pool/pond/lake	1.5%	4.3%	3.3%	5.2%	16.9%	8.2%
River/stream/canal	13.5%	10.7%	6.6%	14.4%	6.9%	8.9%
Other source	0.4%	1.0%	2.4%	1.7%	0.7%	1.4%

The main sources for non-drinking water, i.e., for other domestic purposes such as bathing, cooking, and washing is more or less the same as drinking water sources, with tubewell boreholes used by 40% of households and protected springs by 16%, and river, streams, and canals by 11% of households (Figure 46).

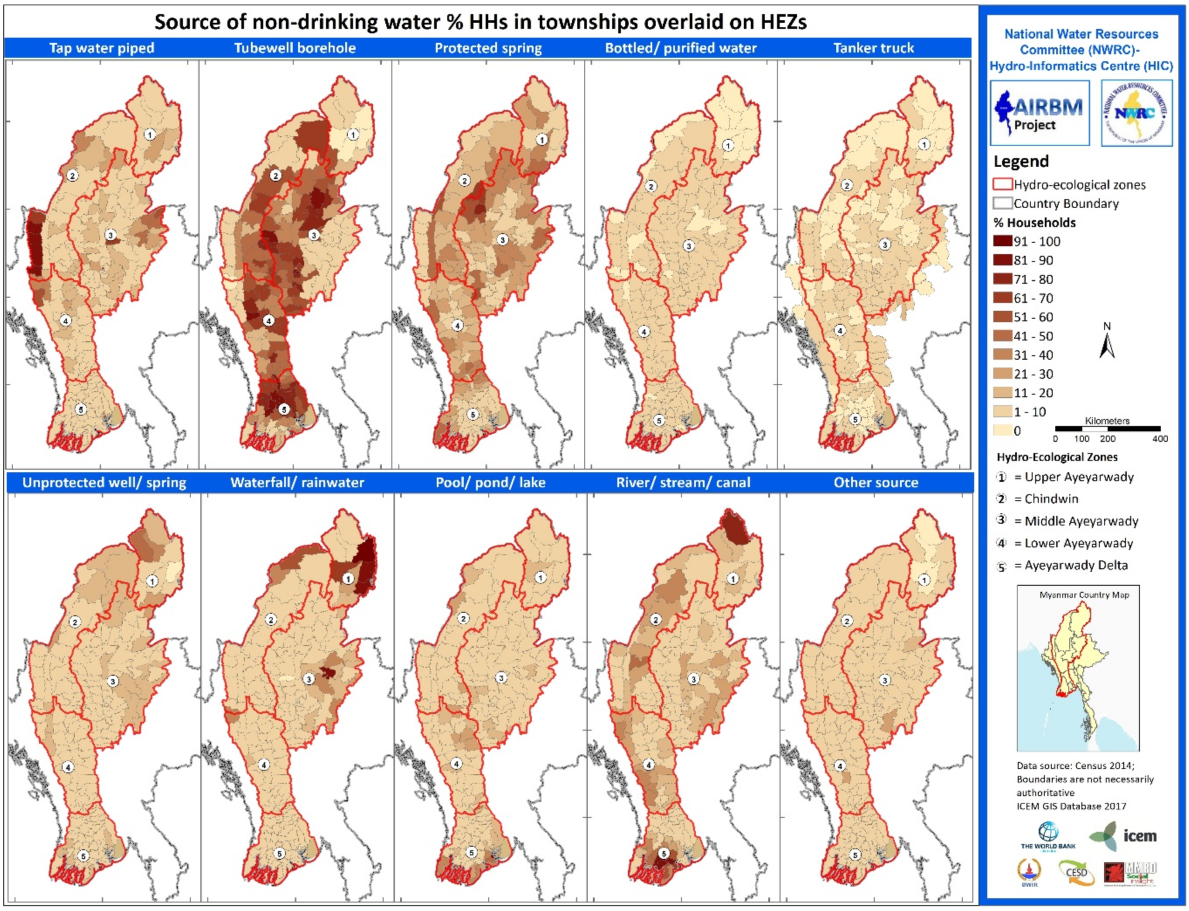


Figure 46 - Source of non-drinking water % HHs in townships overlaid on hydro-ecological zone *(UNFPA 2014)*

Table 32 - Source of non-drinking water *(UNFPA 2014)*

	Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta	All
Source of non-drinking water	**Mean % HHs in townships**					
Tap water piped	7.2%	19.7%	13.0%	9.2%	23.0%	16.3%
Tube well borehole	2.0%	30.3%	43.0%	44.6%	44.9%	40.4%
Protected well/spring	15.3%	22.1%	20.3%	18.3%	7.2%	15.6%
Bottled/purified water	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%
Tanker truck	0.0%	0.1%	0.3%	0.4%	0.0%	0.2%
Unprotected well/spring	15.3%	5.4%	4.7%	2.7%	2.1%	4.0%
Waterfall/rainwater	42.8%	4.8%	5.1%	2.0%	0.1%	4.5%
Pool/pond/lake	1.5%	5.3%	3.9%	6.6%	9.9%	6.4%
River/stream/canal	15.5%	11.3%	7.2%	14.3%	12.1%	10.9%
Other	0.3%	1.1%	2.4%	1.9%	0.6%	1.4%

Approximately 75% of households in the Ayeyarwady Basin had access to safe drinking water in 2014, except in the Upper Ayeyarwady where only 26% had access. Access to safe sanitation is generally quite high, as between 83% and 90% of households in the Ayeyarwady Basin have access (Figure 47; Figure 50; Table 33).

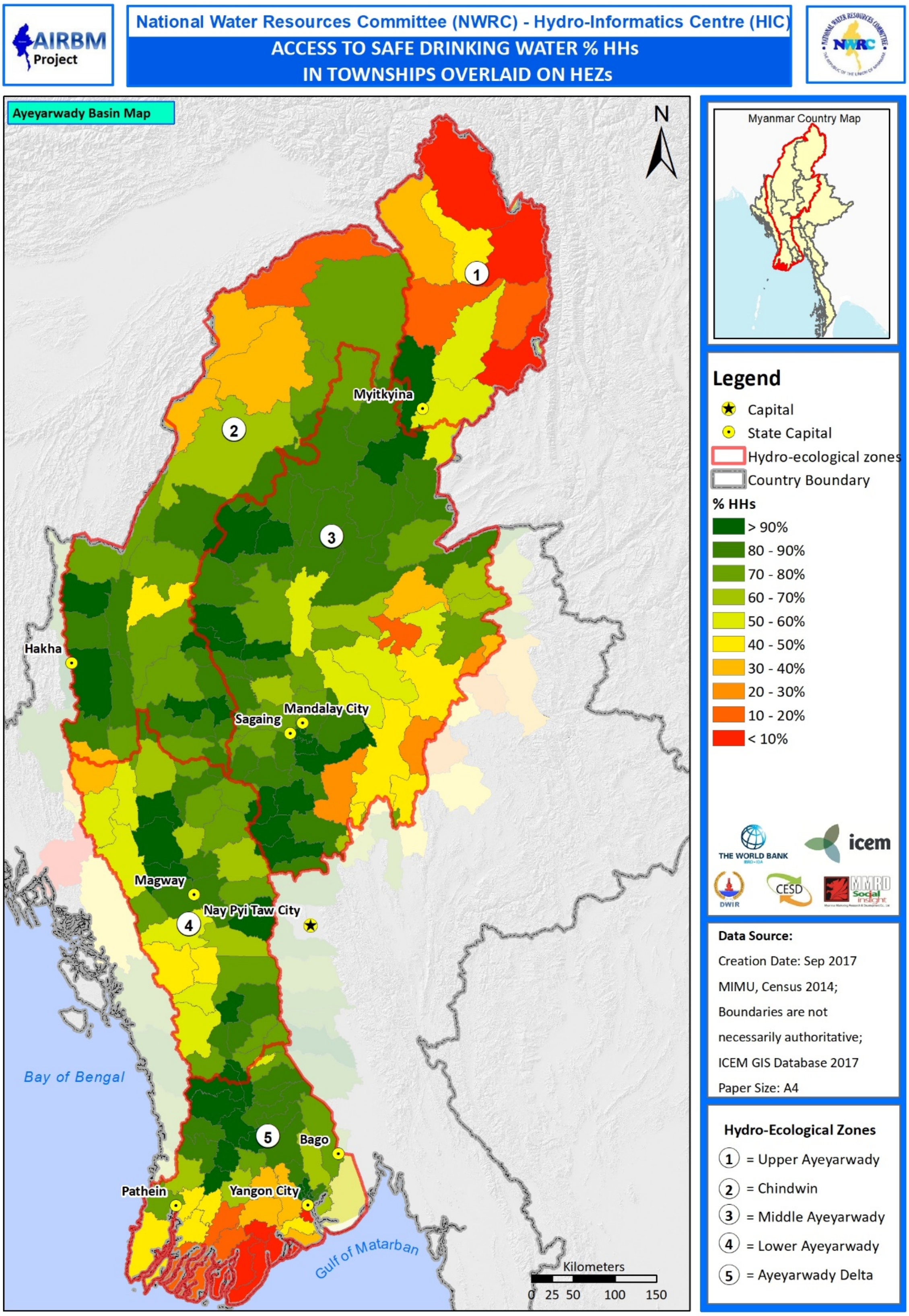


Figure 47 - Access to safe drinking water % HHs in townships overlaid on hydro-ecological zones

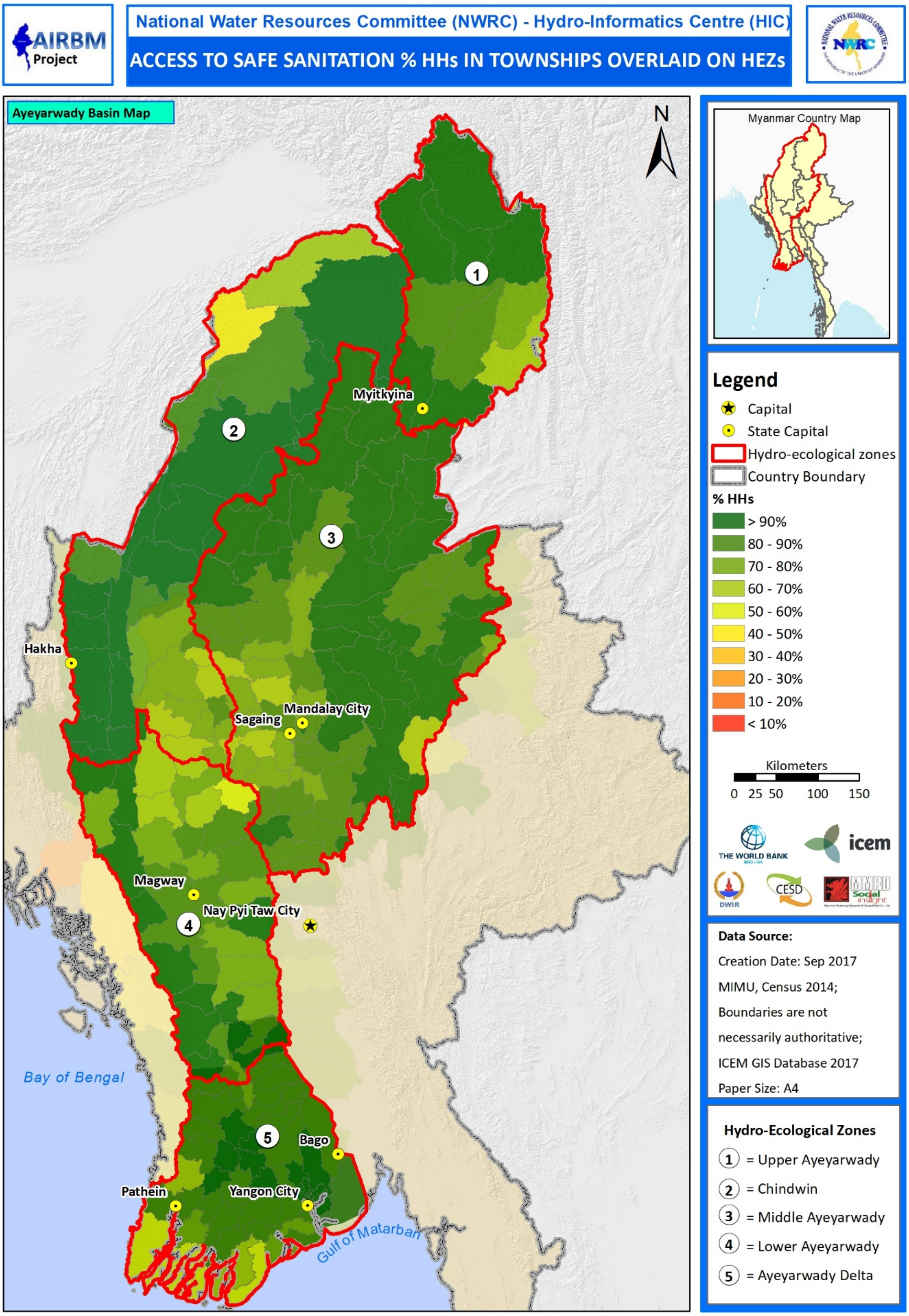


Figure 48 - Access to safe sanitation % HHs in townships overlaid on hydro-ecological zones

Safe drinking water comprises the following sources: piped tap water, tubewell boreholes, protected wells/springs, bottled/purified water, and tanker trucks.

Safe sanitation comprises the following: flush toilets, water seal improved pit latrines, and traditional pit latrines.

Table 33 - Access to safe drinking water and sanitation mean % HHs by hydro-ecological zone *(UNFPA 2014)*

Ayeyarwady Basin HEZ	Access to safe drinking water	Access to safe sanitation
	Mean % HHs in townships	
Upper Ayeyarwady	26.4%	88.9%
Chindwin	73.2%	84.6%
Middle Ayeyarwady	77.8%	87.5%
Lower Ayeyarwady	73.6%	82.8%
Delta	73.1%	89.9%
All	72.6%	87.1%

4.6.4 *Housing Durability*

Housing durability across the Ayeyarwady Basin is currently poor, with only 17% of households deemed to be durable (pukka and semi-pukka) structures. A pukka building refers to an apartment, condominium, bungalow, or brick house. Semi-pukka usually refers to a structure built from a combination of timber frame and brick or concrete inserts. All of these constructions usually have a metal sheeting, tiled, or concrete construction roof.

The remaining 83% of the Ayeyarwady Basin respondents in the 2014 census indicated that they lived in a non-pukka dwelling, usually a wooden or bamboo structure with a palm leaf thatched roof, or a small hut.

Many of the Ayeyarwady Basin townships have levels of 90% or more non-pukka housing. This type of housing is likely to provide little protection for occupants during the cyclones or flooding typical to the southern areas of the Ayeyarwady Basin (in the Ayeyarwady Region and western Bago Region). The larger urban centres of Yangon and Mandalay show significantly higher levels of better durability housing.

5 AGRICULTURE AND IRRIGATION

5.1 Introduction

5.1.1 *Agricultural and irrigation sector*

a) National land and water resources

Myanmar has abundant land and water resources, which can translate into good potential for irrigated agriculture. There is 0.21 ha of agricultural land available per capita and 21,671 m^3 of renewable water per capita, which compares well with other Southeast Asian countries. Myanmar has an uneven spatial and temporal water distribution, as water availability follows the pattern of rainfall, which means that approximately 80% of flow occurs during the monsoon season (May to October) and 20% in the dry season (November to April). Myanmar's irrigation dam capacity is rather small when compared to that of Thailand and Laos (see Table 34).

Table 34 - Land and water resources in Southeast Asia *(World Bank 2017b, FAO 2017a and Ministry of Agriculture, Livestock and Irrigation [MOALI], 2016)*

Country	Agricultural land per capita (ha)	Water resources per capita (m^3/y)	Dam capacity per capita (m^3)
Myanmar	0.21	21,671	305
Ayeyarwady Basin	0.22	-	272
Thailand	0.25	6,454	1,017
Laos	0.23	49,030	1,207
Cambodia	0.25	30,562	-
Vietnam	0.07	9,461	310

The north-south direction of Myanmar's mountain ranges is reflected in the flow of its major rivers, of which the Ayeyarwady-Chindwin River Basin, almost entirely located in Myanmar, drains 58% of the territory. The other main river basins in Myanmar are mentioned in Table 35.

Table 35 - River basins in Myanmar *(MOALI, 2011)*

River basin	Length (km)	Catchment area (1,000 km^2)	Annual surface water (km^3)
Ayeyarwady-Chindwin	2,900	404	455
Sittoung River	320	48	81
Rivers in Rakhine State	-	58	139
Rivers in Tanintharyi Division	-	41	131
Thanlwin River (from Myanmar boundary to its mouth)	1,224	158	258
Mekong River (within Myanmar territory)	350	29	18
Total	-	**738**	**1,082**

Rainfall in Myanmar is unevenly distributed, ranging from 5,000 millimetres per year (mm/y) in Thandwe in the southwest to only 1,000 mm/y in Mandalay and Magway regions, which together compose most of the CDZ. This area has received much of the surface, lift irrigation[12], and groundwater irrigation investments.

Only 18% of Myanmar's 67.6 million ha is cultivated, and 67% of the population is considered rural. The population density is low, at 80 inhabitants per km^2, although there is a great deal of variation across the country. The prevalence of undernourishment is 14%. Total annual water withdrawal is 33.23 km^3, of which

[12] Lift irrigation is irrigation typically pumped up from rivers to the floodplain during the dry season.

89% is for agriculture, 10% is for municipal water supply, and 1% is for industrial water supply. GDP per capita in 2014 was US$ 1,204 (FAO 2017b).

b) National Agricultural production

Myanmar is experiencing a rapid decline in the relative importance of the agricultural sector as its growth is outstripped by that in the industrial and service sectors. Nevertheless, agriculture still accounts for approximately 27% of GDP. In 2015/2016 the Agricultural (crops) sector contributed 20.1% to GDP, whereas the Livestock and Fishery sector contributed 8.5% (MOALI, 2016). Nearly 75% of total households are rural households engaged in subsistence farming activities. They grow cereals such as rice, wheat, and corn for household consumption. Vegetables are produced from backyard gardens or edible leaves and shoots can be easily accessed from nearby farms. However, farmers cannot produce fish from their rice farms because they use large quantities of chemical fertilizers and pesticides (Myanmar Census of Agriculture, 2010).

The Agricultural sector remains the critical sector for employment and poverty reduction. Current estimates suggest that it accounts for 60 - 70% of employment. While this has declined, it is expected to be the major source of employment for the foreseeable future. Similarly, agriculture is critical in addressing poverty. Rural poverty rates stand at 36%. Among the rural poor, approximately 70% of income is spent on food. Agriculture in Myanmar is changing rapidly. While traditional, subsistence farming systems and approaches still prevail they are increasingly existing alongside more modern commercial approaches. Commercial approaches to agriculture are characterized by higher levels of inputs, mechanization, the increased use of wage labour, and the consolidation of land holdings. Commercialization has been developing among smaller farmers as better productivity enables the generation of crops surplus to subsistence needs, and the development of infrastructure and growth in urban populations provides access to large markets for this surplus. At the same time other forms of commercialization, such as agribusiness concessions and contract farming have also been developing rapidly (International Centre for Environmental Management [ICEM], 2017).

c) Irrigation

The Irrigation Department, which was established to coordinate the development and management of water resources for irrigation, has constructed approximately 200 irrigation projects, which receive water from constructed dams, weirs, and sluices. A surface water runoff of approximately 15.46 km^3 has been stored in the constructed reservoirs and can irrigate approximately 1 million ha (Naing, 2005).

5.1.2 Access to land

a) Land holding sizes

Holding sizes and number of parcels have been presented in the 2010 Agricultural Census on a national level. A comparison between 2003 and 2010 is presented in Table 36. The total area of the parcels increased by almost 50% to 12.7 million ha and the average area of the parcels in all holding-size categories increased, whereas the total number of parcels in the larger holding-size categories decreased. Myanmar distinguishes itself in this respect with other countries, where often a decrease in agricultural areas is seen in combination with land fragmentation due to inheritance.

Table 36 - Changes in holding sizes 2003-2010 *(Calculated from Myanmar Census of Agriculture 2010 data)*

Holding size category	2003			2010			Change 2003 - 2010 (%)		
	Total number of parcels	Total area of parcels (ha)	Average area per parcel (ha)	Total number of parcels	Total area of parcels (ha)	Average area per parcel (ha)	Total number of parcels	Total area of parcels	Average area per parcel
Under 0.4 ha	575,452	58,294	0.10	644,443	126,066	0.20	12	116	93
0.4 - 1.2 ha	1,483,392	578,503	0.39	3,122,716	2,109,219	0.68	111	265	73
1.2 - 2.0 ha	1,362,840	974,962	0.72	1,611,338	2,400,652	1.49	18	146	108
2.0 - 4.0 ha	1,877,209	2,231,924	1.19	1,444,152	3,762,581	2.61	-23	69	119
4.0 - 8.0 ha	1,294,639	2,756,353	2.13	545,864	2,783,694	5.10	-58	1	140

Holding size category	2003			2010			Change 2003 - 2010 (%)		
	Total number of parcels	Total area of parcels (ha)	Average area per parcel (ha)	Total number of parcels	Total area of parcels (ha)	Average area per parcel (ha)	Total number of parcels	Total area of parcels	Average area per parcel
8.0 - 20.0 ha	445,212	1,793,025	4.03	123,674	1,331,553	10.77	-72	-26	167
Over 20.0 ha	17,001	182,921	10.76	9,413	280,533	29.80	-45	53	177
Total/average	7,055,745	8,575,982	1.22	7,501,600	12,794,298	1.71	6	49	40

5.1.3 *Land tenure*

There are three major types of land tenure in Myanmar identified in the Agricultural Census, these are:

1) Owner-like - the legal ownership-like possession that provides statutory security of using the land (96.7% in 2010);
2) Trespassed/squatter - lands belong to the government but are occupied without permission to use the land (2.9% in 2010); and
3) Other - land tenure composed of various types, such as land registered to other households but rented by the holder, etc. (0.4% in 2010; Myanmar Census of Agriculture 2010).

Until 30 August 2012, Myanmar legislation regulating farm land ownership comprised the Land Nationalization Act of 1953 and the Tenancy Act of 1963. The gist of the acts are that all agricultural land possessed by non-agriculturist landowners, as well as those portions of land owned by farmers in excess of permitted holding limits, are to be expropriated by the state for redistribution to tillers who have no land of their own. The redistribution, however, does not necessarily mean creating new owner-farmers, but the land thus expropriated under the act is to belong solely to the state, the farmers being given only the right to cultivate by the land committee. The act also forbade farmers from selling, mortgaging, or leasing their land.

The 1953 laws were repealed by the new 2012 Farmland Law. Now the entire parcel owned by holdings will have to be registered legally and this Law allows the holders to sell, mortgage, lease, exchange, and give the whole or part of the right to use the farmland in accordance with the stipulated terms and conditions by registering the transferable deeds. Currently a process is underway to provide farmers with land certificates under this new law.

5.2 Ayeyarwady Basin

5.2.1 *Hydro-ecological zones*

The Ayeyarwady Basin has a total area of 411,000 km^2, which is located in nine states or regions in Myanmar and includes some area in China (5% of the basin) and India (4%).[13] For the purpose of this study five HEZ are considered: Upper, Middle, and Lower Ayeyarwady, Chindwin and Delta. The distribution of these zones over the states/regions is presented in Table 37. In Myanmar the Ayeyarwady Basin shares areas with 44 districts and 213 townships.

Table 37 - Overlay of states/regions with hydro-ecological zones of Ayeyarwady basis (km^2) *(ICEM)*

State/region	Area	Area in the Ayeyarwady Basin	Area in hydro-ecological zones				
			Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Ayeyarwady Region	33,698	32,761	-	-	-	1,526	31,235
Bago Region (West)	14,920	14,224	-	-	-	9,041	5,183
Chin State	24,650	16,589	-	12,667	-	3,922	
Kachin State	88,980	88,977	45,977	16,506	26,494	-	-
Magway Region	43,320	43,320	-	5,398	-	37,244	679

[13] Only townships that have more than 25% of their area in the Ayeyarwady Basin are considered in this table, therefore the total areas of the Ayeyarwady Basin may differ slightly according to the source of the data.

State/region	Area	Area in the Ayeyarwady Basin	Area in hydro-ecological zones				
			Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Mandalay Region	28,847	28,847	-	-	23,759	5,088	-
Sagaing Region	94,064	92,859	-	60,778	31,935	146	-
Shan State (North)	56,520	44,605	-	1,960	42,644	-	-
Yangon Region	10,780	10,297	-	-	3,417	-	6,880
Total in Myanmar	395,778	372,479	45,977	97,309	128,250	56,967	43,977
China	5%	21,496	4,490		17,005	-	-
India	4%	17,344	-	17,344	-	-	-
Total Ayeyarwady Basin	-	411,318	50,467	114,652	145,255	56,967	43,977
Total (%)	-	100	12	28	35	14	11

5.2.2 *Main crops*

The FAO (2017) reports on the cultivation of 43 agricultural crops in Myanmar. The total harvested area of these crops increased from 1994 to 2014 by 60% to 16 million ha. The harvested areas per crop are presented for the period 1994 to 2014 on a logarithmic scale in Annex X. In 2014 paddy occupied 42% of the harvested area, followed by dry beans (19%), sesame seed (7%), Pidgeon peas (4%), and groundnuts and sunflower seed (3% each). All other crops have harvested areas of less than 3%.

The planted and harvested paddy area and yields have all increased over the period 2003/2004 to 2010/2011, resulting in a production increase by 2010/2011 of 41%, but have decreased afterwards and were at 22% in 2015/2016 as compared to 2003/2004, see Table 38.

Table 38 - Effective planted area, harvested area, yield and production of paddy in Myanmar *(Myanmar Census of Agriculture 2010 and Annual Reports Department of Agriculture)*

Year	Planted area		Harvested area		Yield		Production	
	1,000 ha	Index	1,000 ha	Index	t/ha	Index	1,000 t	Index
2003/2004	6,545	100	6,530	100	3.54	100	23,142	100
2004/2005	6,860	105	6,810	104	3.61	103	24,758	107
2005/2006	7,392	113	7,387	113	3.75	106	27,691	120
2006/2007	8,128	124	8,078	124	3.81	108	30,932	134
2007/2008	8,093	124	8,015	123	3.89	111	31,459	136
2008/2009	8,097	124	8,081	124	4.02	114	32,582	141
2009/2010	8,070	123	8,061	123	4.05	115	32,691	141
2010/2011	8,050	123	8,015	123	4.05	115	32,588	141
2011/2012	7,593	116	7,124	109	3.80	107	27,037	117
2012/2013	7,241	111	7,208	110	3.86	109	27,815	120
2013/2014	7,284	111	6,949	106	3.87	109	26,866	116
2014/2015	7,172	110	6,884	105	3.92	111	27,003	117
2015/2016	7,212	110	7,098	109	3.99	113	28,307	122

Paddy yields in Vietnam were 5.77 tonnes per hectare (t/ha) in 2015; in Thailand the average paddy yield in 2015 was only 2.58 t/ha. In comparison, in Egypt farmers obtained in 2013/2014 average paddy yields of more than 10 t/ha.

The planted and harvested areas, yields, and production of other important crops in Myanmar in 2015 are presented in Table 39.

Table 39 - Planted and harvested areas, yield, and production other important crops (2015/2016) *(Annual report Department of Agriculture)*

Crop	Planted area	Harvested area	Yield	Production
	1,000 ha	1,000 ha	t/ha	1,000 t
Pulses	4,656	4,653	1.37	6,396
Sesame seed	1,640	1,621	0.59	954
Groundnuts	955	952	1.63	1,556
Sunflower	466	466	0.99	459
Pidgeon peas	53	53	1.88	100

The harvested areas of most crops are rather stable over the period 1994 - 2014, with exceptions: jute was grown on almost 50,000 ha in 2002 and had almost disappeared in 2014; cashew nuts have more than doubled since 2001 to 1,623 ha in 2014; rubber increased from 43,000 ha in 1994 to 256,000 ha in 2014; and dry beans increased from 900,000 ha in 1994 to 3 million ha in 2014.

5.3 Agriculture in the Ayeyarwady Basin

5.3.1 Land use

Land use in the Ayeyarwady Basin and its HEZs is presented inTable 40. The main land use type is forest (62%) with highest occurrence in the Upper and Middle Ayeyarwady and Chindwin zones. With 17%, rainfed single cropping is the most common type of agriculture. Of the irrigated crops, double cropping covers almost 4% of the area; all irrigated crops together cover almost 6%. Most irrigation takes place in the Middle Ayeyarwady (29%) and Delta (57%) zones. Water-managed/non-irrigated (flood protected) double and single cropping cover 3.5% of the Ayeyarwady Basin and occur mainly in the Chindwin, Lower Ayeyarwady, and Delta. The distinction between the presented categories is based on the interpretation of satellite imagery and is hence not very precise.

Table 40 - Land use in the Ayeyarwady Basin and its hydro-ecological zones (km²)

(ICEM, 2017)

Land Use	Area in hydro-ecological zones					Total	Percent
	Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta		
Rainfed - single crop	659	12,026	32,875	21,071	4,284	70,916	17.12
Rainfed - double crop	-	-	18	4	-	22	0.01
Flood plain - single crop	1	43	213	88	339	684	0.17
Flood plain - double crop	3	91	217	68	7	386	0.09
Water managed (non-irrigated) - double crop	44	422	1,846	268	6,341	8,922	2.15
Water managed (non-irrigated) - single crop	35	1,115	2,502	555	1,580	5,787	1.40
Irrigated - single crop	11	109	297	191	5,295	5,902	1.43
Irrigated - double crop	113	1,562	6,206	987	7,110	15,978	3.86
Irrigated - triple crop	4	153	366	310	1,363	2,195	0.53
Plantation	48	73	932	6	10	1,068	0.26
Grasslands and barren areas	78	859	336	771	-	2,044	0.49
Shrublands and scattered trees	1,401	2,952	10,472	12,274	2,438	29,538	7.13
Forest	47,113	95,139	86,843	20,170	9,536	258,802	62.49
Settlement	13	77	178	60	1,176	1,504	0.36
Water body	286	979	1,986	1,015	2,268	6,535	1.58

Land Use	Area in hydro-ecological zones					Total	Percent
	Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta		
Wetland	25	304	617	196	405	1,547	0.37
Snow	2,326	1	-	-	-	2,327	0.56
Total	52,160	115,904	145,905	58,033	42,152	414,155	100.00

a) Development of agricultural land

The Ayeyarwady Basin has almost 7.5 million ha of agricultural land (Agricultural Census 2010), most of which is located in the Middle and Lower Ayeyarwady and Delta zones. Agricultural land in the Ayeyarwady Basin increased by almost 13% in the period 2003 to 2010, especially in the Chin (50%) and Kachin (90%) states (Table 41).

Table 41 - Agricultural land in the Ayeyarwady Basin in 2010 (ha) and increase from 2003 to 2010 (%)

(Calculated from Myanmar Census of Agriculture 2010 and ICEM data)

State/region	Total	Area in the Ayeyarwady Basin	Area In hydro-ecological zones (ha)					Increase from 2003 to 2010 (%)
			Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta	
Ayeyarwady	2,130,720	2,071,472	-	-	-	96,499	1,974,973	6.13
Bago (West)	678,670	647,008	-	-	-	411,256	235,753	18.77
Chin	139,210	93,686	-	71,536	-	22,149	-	50.87
Kachin	467,420	467,406	241,522	86,707	139,178	-	-	90.91
Magway	1,298,660	1,298,647	-	161,808	-	1,116,498	20,341	9.48
Mandalay	1,541,890	1,541,890	-	-	1,269,929	271,961	-	2.72
Sagaing	2,158,240	2,130,603	-	1,394,517	732,736	3,349	-	19.52
Shan (North)	669,770	528,571	-	23,232	505,339	-	-	33.90
Yangon	648,320	619,301	-	-	205,524	-	413,776	2.36
Total	9,732,900	9,398,584	241,522	1,737,800	2,852,707	1,921,712	2,644,843	13.60
% of total	100	97	2	18	29	20	27	-
% of Ayeyarwady Basin	-	100	3	18	30	20	28	-

b) Vacant, fallow, and virgin lands

According to the Union Land Stock assessment by the Settlement and Land Records Department (Myanmar Census of Agriculture, 2010) Myanmar still has ample potential to increase its agricultural area, as there is vacant, fallow, and virgin (VFV) land in all states/regions. In the Ayeyarwady Basin the extent of potential land ranges from 4 - 42% per HEZ and from 1 - 76% per state/region. Especially in Chin state and in Shan state there is much potential land available (Table 42). In Figure 211 these VFV lands are shown at zone/state level as potential agricultural land. The issues around land allocation for agriculture and forestry are covered further in Chapter 6 on forestry.

Table 42 - VFV land (ha, 2010)

(Calculated from Myanmar Census of Agriculture 2010 and ICEM data)

State/region	Total	Area in Ayeyarwady Basin	Area in hydro-ecological zones					Percentage of state
			Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta	
Ayeyarwady	180,090	175,082	-	-	-	8,156	166,926	5
Bago (West)	79,720	76,001	-	-	-	48,308	27,693	5
Chin	1,670,580	1,124,268	-	858,468	-	265,800	-	68
Kachin	4,027,920	4,027,802	2,081,278	747,181	1,199,343	-	-	45
Magway	1,111,700	1,111,689	-	138,513	-	955,763	17,413	26
Mandalay	411,170	411,170	-	-	338,647	72,523	-	14
Sagaing	1,910,970	1,886,499	-	1,234,747	648,787	2,965	-	20
Shan (North)	2,592,880	2,046,257	-	89,937	1,956,320	-	-	46
Yangon	4,450	4,251	-	-	1,411	-	2,840	0
Total	11,989,480	10,863,018	2,081,278	3,068,846	4,144,508	1,353,515	214,872	-
Average%	-	-	19	28	38	12	2	29

In the period 2003 - 2010 in the Ayeyarwady Basin the agricultural area has increased with 13% (162,000 ha, see a). More than 1,000 acres (250 ha) of vacant land in Sagaing Region will be reclaimed in the 2017 - 2018 fiscal year. The projected land reclamation of 300 acres (120 ha) of farmland in Tamu Township and 780 acres (312 ha) of farmland in Khamti and Minkin townships will be implemented by the Sagaing Region Agricultural Mechanisation Department, with plans to spend Kyat 500 million contributed by the government plus financial support from the LIFT Fund. Reclamation of agricultural land has been made in the region since 2016 - 2017 with government funds, with the intention of direct benefit to farmers without land. A total of 500 acres (200 ha) of farmland in Katha and Yeu towns as well as Honmalin Township in the upper Chindwin area have successfully been reclaimed in the 2016 - 2017 fiscal year.

However, all lands are likely to be used by some local people to support their livelihoods and they are likely to be disadvantaged by agricultural intensification, unless interventions include measures to benefit current users. Lands legally held by the state may be common pool resources, including lands held by local people under customary institutions, that landless people like swidden squatters or smallholder farmers use as a critical part of their livelihoods. There is insufficient information available as to the actual use of the vacant or virgin lands.

c) Swidden agriculture

Swidden or shifting cultivation is still common in upland, hilly, and remote areas in Myanmar, with this farming system most common in Kachin, Chin, and Shan states. Swidden systems are diverse, complex, and dynamic, and are often difficult to define, categorise, measure, and regulate. For these reasons estimates of the extent of swidden agriculture are uncertain.

The Department of Agriculture estimated the net swidden sown area as approximately 270,000 ha in 2014/2015 (approximately 2% of net sown area or 0.4% of total land area). These figures are likely to be an underestimate of the significance and impact of swidden systems. First, these figures only take into account the area under cultivation that year. Land is typically rested and left fallow in a swidden rotation for any length of time from 3 - 20 years. The area of land under swidden systems could therefore be anything from 3 - 20 times the area currently cultivated. Second, these figures are net of 'squatters', meaning they do not include unofficial land users. This may make up the majority of swidden cultivation. Figures from the Forest Department [FD] of Myanmar dating from 1993 suggest that approximately 15 million ha (22.8% of total land area) was affected by shifting cultivation. These figures are likely to be inclusive of fallow land and unofficial land use. Other sources from the last two decades estimate figures from 0.29 million ha to 10.18 million ha. Figures for households dependent upon swidden agriculture are similarly vague, although Forestry Department estimated that between 1.5 million and 2 million households practiced swidden agriculture in 1995. Nevertheless, it is clear that swidden systems remain an extremely important agricultural system and livelihood strategy in many upland areas in Myanmar (ICEM, 2017).

Despite the importance of swidden systems for land management in upland areas, there is no breakdown of swidden areas per district or state/region, therefore no estimate can be provided of the areas of swidden agriculture per HEZ of the Ayeyarwady Basin.

d) Riverbank gardens

In Myanmar the cultivation of riverbanks, islands, and other seasonally available in-stream structures during the dry season represents an important source of agricultural production for riparian communities. Recession agriculture is commonly practiced on these areas, which in the Ayeyarwady Basin can be quite large. Riverbank gardens become available for cultivation as the water level recedes in the dry season and are used for the cultivation of a range of subsistence and cash crops. They are particularly attractive for cultivation because the fertility of the soil is replenished every year by nutrients from sediments deposited during the wet season; seasonal flooding also means areas are largely free of weeds; these areas have easy and reliable access to water; and they provide a reliable source of production to households during the dry season. Riverbank gardens can be substantial with large areas of alluvial deposits forming seasonal islands and sandbanks which may also be cultivated in a similar manner. Unfortunately, there are no estimates of their extent (ICEM, 2017). It is suggested to prioritize work to quantify the location, extent, and production from riverbank gardens.

Box 1 - Potential for organic agriculture in the Ayeyarwady Basin

Organic foods are defined as foods that are free of artificial food additives and often processed with fewer artificial methods, materials, and conditions such as chemical ripening, food irradiation, and genetically modified ingredients.

Farmers in Myanmar already use less chemical fertilizers and pesticides compared to other countries in the region, yet many are reluctant to venture into the organic market due to transport hindrances and high costs.

Organic produce must be certified for quality before being cleared for sale in overseas markets. To date, only three companies have been certified organic by the International Federation of Organic Agriculture Movements, among them, Sein Le Oo Organic Farm, and Genius Shan Highlands Coffee. The latter, which produces organic coffee, is recognized as an organic company by the Government of Myanmar as well as the United States Department of Agriculture.[14]

There seems to be good potential for organic food produced in Myanmar, especially in more remote areas where there is no danger of pesticide pollution from neighbouring or upstream farms. In Egypt, for example, a bio-dynamic farm and processing unit (Sekem) has ample experience in using out growers for part of its primary production.

Integrated Pest Management has been introduced recently in Myanmar on a pilot basis in 69 villages of 69 districts. If successful, this practice will be extended to other villages and can help to reduce the reliance on harmful pesticides. The current use of these pesticides reduces the possibility of organic agriculture and of integrated land use such as rice-fish culture.

e) Rice cultivation in the Ayeyarwady Basin

Covering 7.7 million ha, paddy is by far the most important crop in Myanmar (Agricultural Census 2010), totaling 55% of cropped area. In Ayeyarwady State paddy covers 95% of agricultural land. The annual growth of the paddy area in the Ayeyarwady Basin between 2003 and 2010 was 5.2% (Table 43). The paddy areas are shown in Figure 216. In 2010, the planted paddy area in the Ayeyarwady Basin of 4.9 million ha was 52% of the nationally planted paddy area (see Table 43).

[14] www.mmtimes.com/index.php/business/27209-myanmar-can-raise-value-volume-of-agriculture-exports-by-going-organic.html

Table 43 - Net planted paddy area (ha, 2010)

(Calculated from Myanmar Census of Agriculture 2010 and ICEM data)

State/ region	Total	Area in Ayeyarwady Basin	Paddy area in hydro-ecological zones					Paddy % of agricultural area	Annual growth 2003 - 2010 (%)
			Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta		
Ayeyarwady	2,018,050	1,961,935	-	-	-	91,396	1,870,539	95	0.83
Bago (W)	555,450	529,537	-	-	-	336,588	192,949	82	5.07
Chin	56,250	37,855	-	28,905	-	8,950	-	40	3.93
Kachin	266,880	266,872	137,900	49,506	79,466	-	-	57	8.65
Magway	369,350	369,346	-	46,020	-	317,542	5,785	28	10.60
Mandalay	328,270	328,270	-	-	270,369	57,901	-	21	2.92
Sagaing	788,160	778,067	-	509,259	267,585	1,223	-	37	4.83
Shan (N)	197,080	155,532	-	6,836	148,696	-	-	29	1.73
Yangon	542,980	518,676	-	-	172,131	-	346,545	84	-0.06
Total	5,122,470	4,946,091	137,900	640,526	938,247	813,599	2,415,819	53	5.22
% of Total	100	97	3	13	18	16	47	-	-
% of Ayeyarwady Basin	-	100	3	13	19	16	49	-	-

The cropping pattern of full control irrigated crops in Myanmar is presented in Table 44. Paddy is by far the most important irrigated crop and can be grown twice a year. Other important crops are oil crops (sesame and other), pulses, and cotton. The cropping intensity of the full control irrigated areas is 133%.

Box 2 - Floating rice

Floating rice (deep water rice) was once widely distributed in both shallow and deep flooded areas across the Mekong River Delta in Vietnam, particularly the in the Long Xuyen Quadrangle and the Plain of Reeds. Despite the almost complete disappearance of floating rice in Vietnam, it is important to note that since 2012 the area of floating rice has been steadily growing as its benefits become more widely recognized. In floating rice cultivation farmers prepare their paddies in the dry season for the next wet season rice crop by burning any remaining rice straw and then ploughing usually using two water buffaloes. When the first rains fall, they cultivate again by harrowing and then sowing floating rice by broadcasting at a rate of 100 kg rice seeds/ha. The farmers then harrow again to cover the seed to prevent bird and mice damage, and maintain good soil moisture for germination. During the flood season the rice plants elongate their stems keeping the developing flowering heads above the water. Farmers report that floating rice can grow up to 0.1 m a day during rapidly rising flood times. When the flood water recedes in November, the rice plant falls flat on the ground and then flowers. The rice is harvested by sickle between December and January. Some farmers use the remaining soil moisture and silt deposit from the flood to cultivate dry season crops such as sesame, watermelon, and mung bean, to be harvested before the next flood event.

Myanmar has the largest cultivated areas of floating rice in Southeast Asia. In the Ayeyarwady Basin floating rice is found in Bago (217,379 ha), Yangon (98,811 ha), and the Ayeyarwady Delta (329,982 ha). It is important to note that while the areas of floating rice were decreasing in total, in Ayeyarwady, Bago, and Yangon they are increasing. In Myanmar floating rice is at risk due to a range of impacts other than just government agricultural policies. These risks include climate change (abnormal floods and droughts), lack of market as human food (floating rice is primarily used as feed for livestock), lack of farmer knowledge about integrated floating rice-based farming systems that include profitable dryland vegetable crops and fish, and lack of suitable genetic material among traditional floating rice varieties in Myanmar, which prevents crop adaptation to mitigate risks from changing flood regimes (Nguyen and Pittock, 2016)

Table 44 - Cropping pattern for full control irrigation in Myanmar, 1,000 ha, 2006

(FAO 2017a)

Irrigated crops	Area	Crop area as percentage of the full control actually irrigated area by month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wheat	77	4	4	4	-	-	-	-	-	-	-	4	4
Rice one	692	-	-	-	-	-	33	33	33	33	33	-	-
Rice two	1,226	59	59	59	-	-	-	-	-	-	-	59	59
Maize	22	1	1	1	-	-	-	-	-	-	-	1	1
Vegetables	50	2	2	2	2	2	-	-	-	-	-	-	-
Fruits	31	1	1	1	1	1	1	1	1	1	1	1	1
Sesame	79	4	4	4	-	-	-	-	-	-	-	4	4
Other oil crops	200	10	10	10	10	10	-	-	-	-	-	-	-
Potatoes and sweet potatoes	6	0.3	0.3	0.3	-	-	-	-	-	-	-	0.3	0.3
Pulses	220	11	11	11	11	11	-	-	-	-	-	-	-
Sugarcane	62	3	3	3	3	3	3	3	3	3	3	3	3
Cotton	108	5	5	5	5	5	5	5	-	-	-	-	-
Tobacco	2	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-
Harvested irrigated crop area	**2,775**												
Area equipped for full control irrigation actually irrigated	**2,083**	**100**	**100**	**100**	**32**	**32**	**43**	**43**	**38**	**38**	**38**	**72**	**72**
Cropping intensity (%)	**133**												

5.3.2 *Mechanization*

In Myanmar the mechanization of agricultural practices (ploughing, harvesting, and transport) is still extremely limited; most work is done with bullocks and buffaloes. In the 2014 Census questions covered the ownership of four-wheel tractors, which is used here as a proxy for mechanisation. The survey results have been reported at township level and aggregated at the HEZ level (Table 45). The density of tractors (units per ha agricultural land) is very low (UNFPA 2014).

Efforts are being made by MOALI to totally eliminate the local way of threshing paddy on the trashing ground, by introducing threshers and combine harvesters, and thereby reducing post-harvest losses. The Agricultural Mechanization Department offers a two-year installment plan for agricultural machinery on the basis of a 35% down payment. In paddy cultivation this department also provides farm mechanization services for land preparation, transplanting, harvesting, and threshing to increase rice quality and to reduce losses.

Table 45 - Four-wheel tractors per hydro-ecological zone of the Ayeyarwady Basin

(LIFT 2012 Baseline Survey and ICEM data)

State/region	Four-wheel tractors in the Ayeyarwady Basin	Four-wheel tractors in hydro-ecological zones				
		Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Ayeyarwady	37,196	-	-	-	617	36,579
Bago (W)	6,831	-	-	-	3,682	3,149
Chin	160	-	136	-	3	21
Kachin	14,759	1,907	1,889	9,237	1,726	-
Magway	8,331	461	999	27	6,845	-

State/region	Four-wheel tractors in the Ayeyarwady Basin	Four-wheel tractors in hydro-ecological zones				
		Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Mandalay	16,563	-	4	14,776	1,783	-
Sagaing	19,713	-	9,478	10,160	75	-
Shan (N)	22,748	-	3,037	19,711	-	-
Yangon	8,996	-	-	13	-	8,983
Total	135,297	2,368	15,542	53,924	14,731	48,732
Percentage of total	100	1.8	11	40	11	36
Tractors/ha	0.018	0.012	0.015	0.027	0.009	0.019

5.4 Food Production, Security, and Trade

5.4.1 *Rice sufficiency and food balance*

Paddy (rice) is the main staple food in Myanmar, and self-sufficiency is important for food security. On a national scale Myanmar had a paddy surplus of 30% in 2010. All the HEZs of the Ayeyarwady Basin except the Middle Ayeyarwady generate a paddy surplus. This is especially so in the Delta, where the surplus generated is 4.6 Mt. The whole Ayeyarwady Basin has a surplus of 5.4 Mt. In the states/regions of the Ayeyarwady Basin, Chin, Magway, Mandalay, and Yangon are paddy-deficient[15] (Table 46). Paddy sufficiency is shown in Figure 213.

Table 46 - Paddy surplus (t) and sufficiency (%), 2010

(Calculated from Myanmar Census of Agriculture 2010 and ICEM data)

State/region	Total surplus	Surplus in the Ayeyarwady Basin	Paddy surplus in hydro-ecological zones					Sufficiency percentage in state
			Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta	
Ayeyarwady	4,779,151	4,646,259	-	-	-	216,444	4,429,815	234
Bago (W)	1,182,456	1,127,291	-	-	-	716,536	410,755	210
Chin	-77,742	-52,319	-	-39,949	-	-12,369	-	62
Kachin	322,686	322,677	166,736	59,858	96,082	-	-	152
Magway	-327,192	-327,189	-	-40,767	-	-281,297	-5,125	85
Mandalay	-1,307,111	-1,307,111	-	-	-1,076,561	-230,550	-	56
Sagaing	1,346,129	1,328,891	-	869,783	457,019	2,089	-	151
Shan (N)	63,699	50,270	-	2,209	48,060	-	-	107
Yangon	-333,990	-319,040	-	-	-105,878	-	-213,162	86
Total	5,648,086	5,469,729	166,736	851,135	-581,277	410,853	4,622,283	-
Average%	-	100	3.0	15.6	-10.6	7.5	84.5	-

5.4.2 *National Food balance*

In Annex XI the 2013 Food Balance Sheet for Myanmar containing 70 food commodities, is presented and sorted on energy supply. In this sheet the supply of each food commodity is the total of production, plus imports, minus exports, and adjusted for changes in stocks. The food availability consists of the supply minus animal feed, seed, and losses. This food supply is then presented as supply per capita, and the daily per capita

[15] For the calculation of paddy-sufficiency it was assumed that from the paddy production, 0.1 t/ha is used for seed, 6.65% of paddy production is wasted, urban paddy consumption is 251 kg/capita/y, and rural consumption is 313 kg/capita/y.

supply of energy, protein, and fat. The balance sheet shows that in Myanmar rice, with 1,234 out of a total of 2,561 kilo calories per capita per day (kcal/capita/day), is by far (48%) the most important energy supplier for the population. In Table 47 the food balance of the 12 most important food commodities is presented.

Table 47 - Myanmar food balance sheet of most important commodities, 2013

Population: 53.295 million (Compiled and calculated from FAO 2017).

Commodity	1,000 t									Kilogram per capita per day (kg/capita/y)	kcal/ capita/ day	Gram per capita per day (g/capita/day)	g/ capita /day
	Production	Import	Export	Stock	Supply	Feed	Seed	Losses	Food	Food	Energy	Protein	Fat
Rice (milled equivalent)	19,188	21	512	-899	19,596	7,882	556	576	7,073	132.8	1,234	28.87	5.5
Sugar non-centrifugal	787	-	-	-	787	-	-	-	787	14.77	145	0.45	0.12
Pig meat	621	-	-	-	621	-	-	19	602	11.31	111	3.44	10.69
Groundnut oil	225	-	-	-	225	-	-	-	225	4.22	102	-	11.55
Pulses	1,469	-	54	-	1,415	496	40	15	544	10.21	97	5.79	0.86
Poultry meat	1,196	1	-	-	1,197	-	-	33	1,165	21.87	83	7.15	5.82
Milk - excluding butter	1,708	93	-	-	1,801	-	-	123	1,677	31.48	50	3.91	2.6
Freshwater fish	1,921	-	8	-1	1,914	-	-	-	1,372	25.77	49	7.71	1.77
Wheat and products	188	206	1	-	393	37	6	19	331	6.22	47	1.16	0.24
Vegetables, other	3,612	1	4	-	3,609	-	-	351	3,258	61.18	46	2.53	0.35
Marine Fish, other	2,110	4	441	-	1,673	62	-	-	1,501	28.19	45	6.44	1.55
Maize and products	1,700	2	77	300	1,325	1,020	14	85	206	3.87	35	0.86	0.32
Other commodities	-	-	-	-	-	-	-	-	-	-	517	13.51	27.97
Total	-	-	-	-	-	-	-	-	-	-	2,561	81.82	69.34

5.4.3 *Key issues in paddy production*

a) Post-harvest losses

Typical post-harvest losses of rice in Southeast Asian countries are estimated to be approximately 10 - 15% in terms of quantities loss. The total loss amounts to 25 - 50% once qualitative loss is added. In Myanmar, 90% of rice mills (including threshers) face quality problems and require modernization of rice milling techniques. Milling losses of approximately 10% take place in middle-scaled rice mills, but losses also occur from the harvester to the millers, and handling at paddy fields are especially problematic.

Rice producing farmers typically leave the harvested paddy on the harvested plot for three weeks to allow for cracking of the grains. This often result in quality problems as insufficient drying during this period leads to yellow colouring of rice grains, which fetches lower prices. In recent years, climatic vagaries resulted in uncommon rainfall during the summer season, requiring the introduction of combined harvesters and the construction of warehouses to enable rapid harvesting and proper storage (Japan International Cooperation Agency [JICA], 2013).

Post-harvest losses of rice along the value chain are presented in Table 48. Most losses occur during production (harvesting, threshing, drying, and transport), and milling (milling, storing, packing, and transport). Apart from losses, poor post-harvest handling of rice leads to decreased quality and a lower value end product.

Table 48 - Post-harvest losses in rice

(Emerging Markets Newsletter, No.24, Daiwa Institute of Research, 2013)

Value chain	Upstream	Midstream			Downstream	
	Production	Collection	Milling	Wholesaling	Retailing	Consumption
Stakeholders	Farmers	Collector	Miller	Wholesaler	Retailer	Consumer
Activities	Harvesting, threshing, drying, transporting	Collecting, storing, transporting	Milling, storing packing, transporting	Storing, trading, transporting	Retailing, transporting	Transporting, processing
Post-harvest	6 - 21%	2 - 6%	2 - 10%	-	-	-

b) Rice marketing and export

Myanmar is still a modest rice exporter when compared to its neighbours and Vietnam; in 2013, Cambodia exported 361,000 t, Myanmar 484,000 t, Vietnam 3.9 Mt, and Thailand almost 6.8 Mt (Figure 49). A logarithmic scale was applied in this graph in order to show Myanmar's export more clearly. Notably, Myanmar and Thailand both exported approximately 1.5 Mt rice in 1961 and Cambodia did not export any rice in the period 1973 - 1995, but is now catching up with Myanmar.

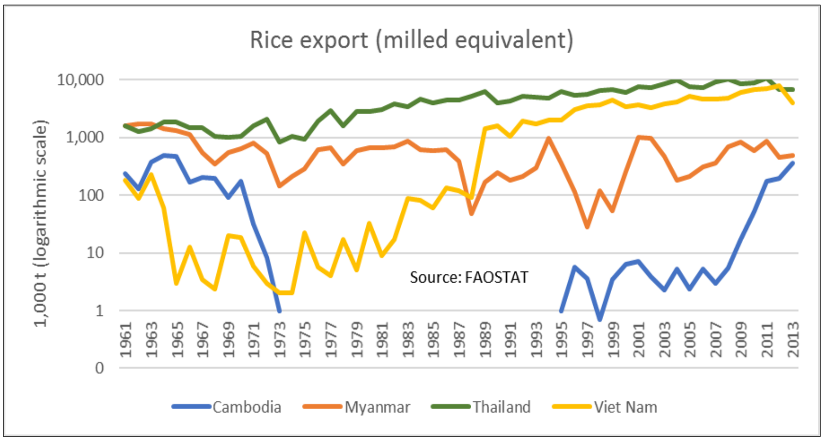


Figure 49 - Rice export of Myanmar and other countries, 1,000 t, logarithmic scale

The destinations of Myanmar's rice exports in 2013 were dominated by African countries (mainly Burkina Faso and Côte d'Ivoire at 44%) and the Russian Federation (18%), rather than to the Asian and European market (Figure 50); Belgium is an exception (8%). This is probably due to poor grain sorting technologies resulting in a higher rate of broken grains. Another factor of quality deterioration may stem from poor cultivation management at paddy parcel level, resulting in intra-varietal crossing and variable grain sizes as well as the discolouring of grains. These factors make rice less marketable in Asia and Europe.

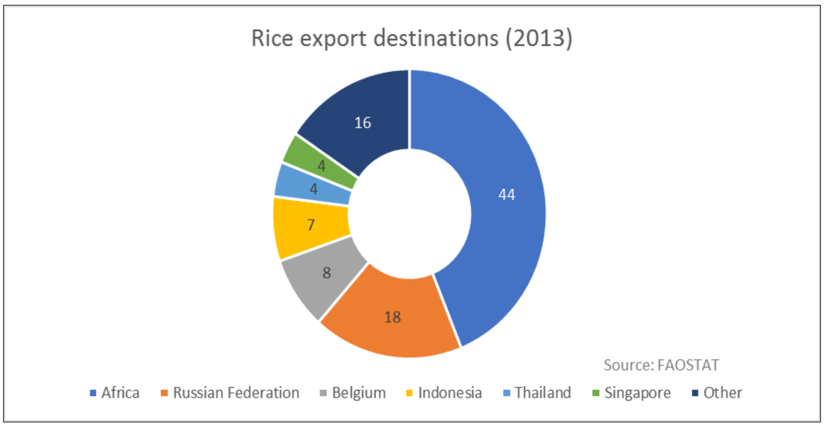


Figure 50 - Myanmar's rice export destinations, % of quantity

5.5 Food Security

Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). This widely accepted definition points to the following dimensions of food security:[16]

- **Food availability** - The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).
- **Food access** - Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic, and social arrangements of the community in which they live (including traditional rights such as access to common resources).
- **Utilization** - Utilization of food through adequate diet, clean water, sanitation, and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security.
- **Stability** - To be food secure, a population, household, or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (e.g., an economic or climatic crisis) or cyclical events (e.g., seasonal food insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security.

The Economic Intelligence Unit annually prepares a Global Food Security Index[17], covering 113 countries. In this index three main components are distinguished: Affordability, Availability, and Quality and Safety. The position of Myanmar as compared to all countries is depicted in Figure 51 and shown in Table 49. Myanmar scores 80 out of 113 (between Philippines and Nepal). The table also shows that the overall index for Myanmar deteriorated since 2017, that Affordability increased, but Availability decreased. The full range of scores, sub-scores, and comparison with all other countries is presented in Annex XII.

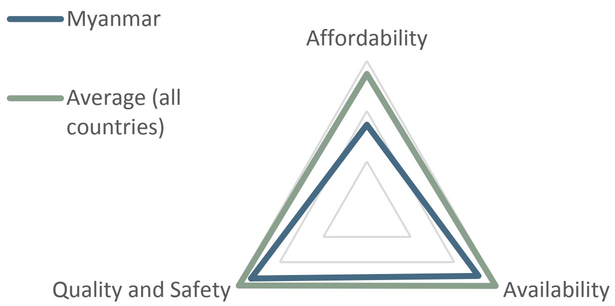


Figure 51 - Food security index Myanmar, 2017

Table 49 - Myanmar Food Security Index 2017

Category	Myanmar			Average score (all countries)
	Score 2017	Change 2016	Rank	
Overall	**44.8**	**-0.7**	**80**	**57.3**
Affordability	34.6	+1.4	84	54.8
Availability	51.1	-2.9	72	59.0
Quality and Safety	53.1	0.0	71	58.7

5.6 Irrigation in the Ayeyarwady Basin

[16] http://www.fao.org/forestry/13128-0e6f36f27e0091055bec28ebe830f46b3.pdf
[17] http://foodsecurityindex.eiu.com/

5.6.1 *Irrigation development*

Irrigation was developed in the CDZ regions of Mandalay region, Sagaing region, and Magway region from ancient times, to enable wet rice cultivation. The Myanmar kings developed irrigation facilities, especially small tanks and river diversion weirs in this region. These systems were rehabilitated and developed again during the colonial period. After 1988, small and medium dams and reservoirs were constructed throughout the country and irrigation facilities were constructed in the delta. On a national scale irrigation from government dams, weirs, sluices, tanks, and lakes are the most prominent irrigation water sources (88%). Private dams and wells and other sources make up the remaining 12% (Myanmar Census of Agriculture, 2010).

Contrary to irrigation in many countries, irrigation in areas outside the Dry Zone in Myanmar is used to supplement the monsoon, especially in the somewhat drier month of July. In the Dry Zone potential evaporation is much larger than precipitation (except in September), making irrigation essential for cultivation. Only some 40% of the areas equipped for irrigation are irrigated during the dry season.

In the Delta, flood protection and drainage are essential for cropping. Water management is done through so-called tidal pumping, in which areas are protected by dikes and sluices. During low-tide, water is drained by gravity, and during high tide the sluices are closed and protect the areas against saline intrusion.

Irrigation efficiency in the Dry Zone seems low: the International Water Management Institute (IWMI) estimates that at best 5% of the water supplied for irrigation actually contributes to crop evaporation (IWMI, 2013).

a) Surface irrigation

The Irrigation and Water Utilization Management Department (IWUMD), which falls under MOALI, is responsible for the construction and management of surface irrigation. In 2016, 92 out of the 212 townships in the Ayeyarwady Basin were equipped to some extent for surface irrigation from 63 dams, 24 weirs, 19 sluices, 11 tanks, and 1 lake with a total area of 971,174 ha; dams are by far the most important source as they supply 65% of surface irrigation (Table 50).

Table 50 - Areas equipped for surface irrigation by source in the Ayeyarwady Basin (ha, 2016)

(Calculated from IWUMD township-level and ICEM data)

State/region	Dam	Weir	Sluice	Tank	Lake	Total
Ayeyarwady Region	19,757	-	157,079	-	-	176,836
Bago Region (West)	114,963	991	2,891	-	-	118,845
Chin State	98	-	-	-	-	98
Kachin State	-	8,812	-	-	-	8,812
Magway Region	40,988	63,622	368	823	-	105,801
Mandalay Region	136,406	38,128	-	22,085	10,642	207,261
Sagaing Region	226,332	2,366	91	590	-	229,379
Shan State (North)	59,195	6,927	-	-	-	66,122
Yangon Region	32,811	-	25,209	-	-	58,020
Total area in the Ayeyarwady Basin	630,550	120,846	185,638	23,498	10,642	971,174
Percent	65	12	19	2	1	100

The total areas equipped for surface irrigation are distributed over the five HEZs: 0.7% in the Upper Ayeyarwady; 2.6% in the Chindwin; 42% in the Middle Ayeyarwady; 27% in the Lower Ayeyarwady; and 28% in the Delta (**Table 51**).

Table 51 - Areas equipped for surface irrigation by hydro-ecological zones of the Ayeyarwady Basin (ha, 2016)

(Calculated from IWUMD township-level and ICEM data)

State/region	Area equipped for irrigation in the Ayeyarwady Basin	Area equipped for surface irrigation in hydro-ecological zones				
		Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Ayeyarwady Region	176,836	-	-	-	6,709	170,127
Bago Region (West)	118,845	-	-	-	77,905	40,940
Chin State	98	-	-	-	13	85
Kachin State	8,812	4,688	831	3,293	-	-
Magway Region	105,801	2,313	3,672	303	99,513	-
Mandalay Region	207,261	-	30	129,681	77,550	-
Sagaing Region	229,379	-	20,462	208,765	152	-
Shan State (North)	66,122	-	474	65,648	-	-
Yangon Region	58,020	-	-	-	-	58,020
Total area in the Ayeyarwady Basin	971,174	7,001	25,468	407,690	261,844	269,171
Percent	100	0.7	2.6	42	27	28

In order to assess which state/regions and HEZ surface irrigation is most prominently developed, the density of the areas equipped for surface irrigation has been calculated by dividing the irrigation hectares by the surface area (km^2) of each township. The aggregated densities are presented in Table 52, showing a range of 0.01 (Chin state) to 8.4 (Yangon region) over the states/regions and a range from 0.14 (Upper Ayeyarwady) to 6.06 (Delta). This irrigation density is presented at township-level in Figure 52, showing that the highest densities occur in the Middle Ayeyarwady and in the delta.

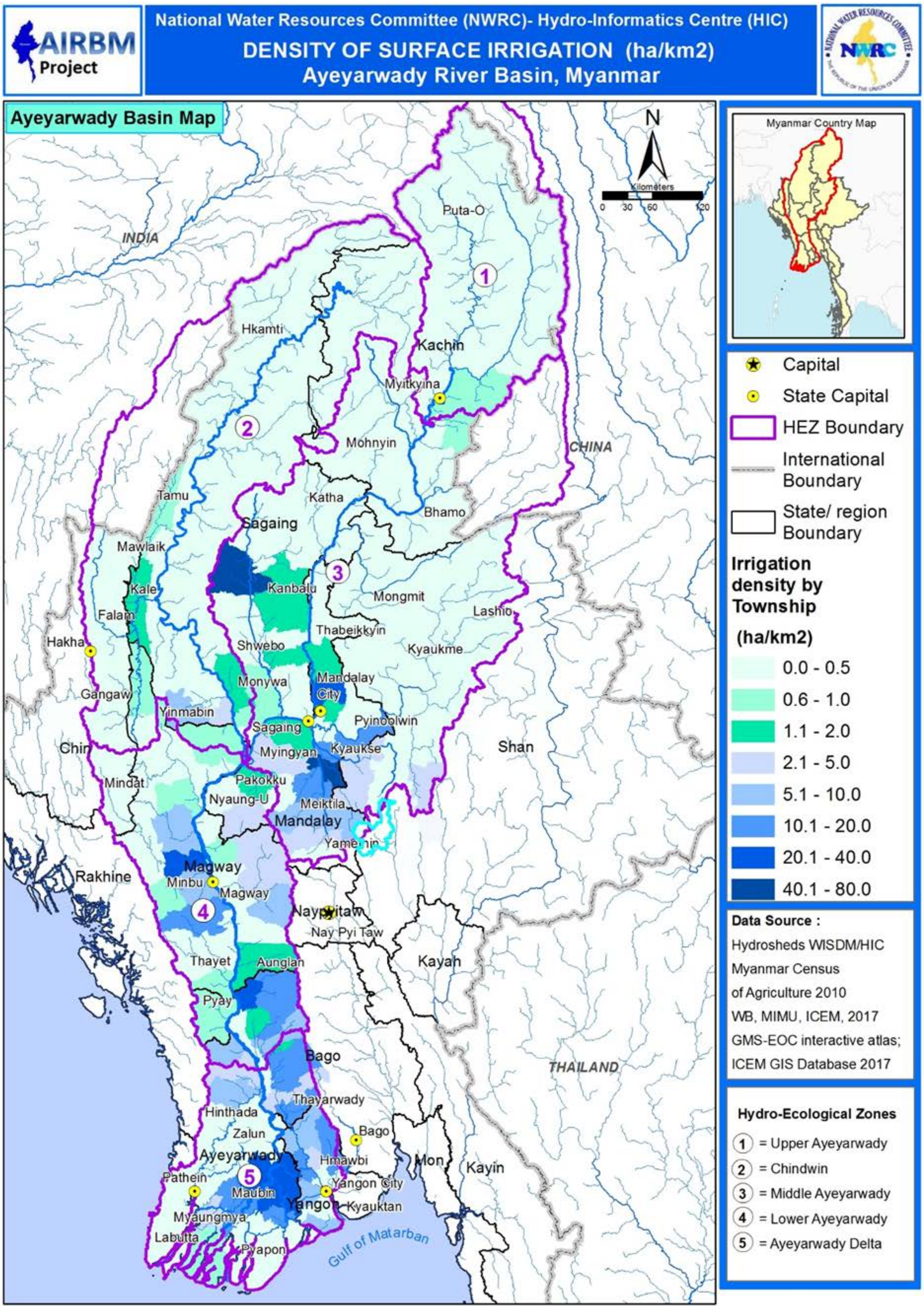


Figure 52 - Density of Surface Irrigation (ha/km²) - Ayeyarwady River Basin, Myanmar

Table 52 - Density of areas equipped for surface irrigation by hydro-ecological zone (ha/km²)

(Calculated from IWUMD township-level and ICEM data)

State/region	Density of area equipped for irrigation in the Ayeyarwady Basin	Density of area equipped for irrigation In hydro-ecological zones				
		Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Ayeyarwady Region	5.40	-	-	-	4.44	5.45
Bago Region (West)	8.36	-	-	-	8.09	8.93
Chin State	0.01	-	-	-	0.05	0.05
Kachin State	0.10	0.10	0.12	0.10	-	-
Magway Region	2.35	0.94	0.71	1.93	2.68	-
Mandalay Region	7.19	-	3.22	5.61	13.59	-
Sagaing Region	2.45	-	0.39	6.26	0.02	-
Shan State (North)	1.44	-	0.11	1.58	-	-
Yangon Region	8.40	-	-	-	-	8.40
Average	2.62	0.14	0.31	3.14	4.09	6.06

The areas that are equipped for surface irrigation are the gross command areas listed by IWUMD. A substantial portion of these areas (IWMI estimates 30%) cannot actually be irrigated for lack of distribution systems within the command areas. With modest additional investments, the irrigated area could be substantially increased by putting the missing water distribution systems in place in combination with land consolidation to ensure irrigation access for all plots within the command area.

Table 53 presents the irrigation density by source, showing that dams and sluices are the most important sources, and that there is only one irrigation scheme that uses a lake (Meiktila Township, Mandalay Region).

Table 53 - Density of surface irrigation in the Ayeyarwady Basin by source (ha/km²)

(Calculated from IWUMD township-level and ICEM data)

State/region	Dam	Weir	Sluice	Tank	Lake	Total
Ayeyarwady Region	0.60	-	4.80	-	-	5.40
Bago Region (West)	8.08	0.07	0.20	-	-	8.36
Chin State	0.01	-	-	-	-	0.01
Kachin State	-	0.10	-	-	-	0.10
Magway Region	0.91	1.41	0.01	0.02	-	2.35
Mandalay Region	4.73	1.32	-	0.77	0.37	7.19
Sagaing Region	2.41	0.03	0.00	0.01	-	2.45
Shan State (North)	1.29	0.15	-	-	-	1.44
Yangon Region	4.75	-	3.65	-	-	8.40
Average density in the Ayeyarwady Basin	1.70	0.33	0.50	0.06	0.03	2.62

IWUMD is implementing land consolidation and mechanization projects in collaboration with other relevant departments of MOALI. In irrigated areas 5,746 ha have been consolidated (2016), but 210,167 ha remain (MOALI, 2016).

Because of deforestation and the resulting erosion in the catchments of many dams, siltation is a severe problem and may jeopardize the functioning of a large number of dams.

b) River lift and groundwater irrigation

The Water Resources Utilization Department (WRUD) was established under MOALI in 1995 to develop irrigation with groundwater and for the installation of river water pumping systems. In the nine states/regions of the Ayeyarwady Basin the Department has currently (2017) 15,771 functioning shallow (<60m) tubewells with a diametre of 2 inches and a combined capacity of 40,000 cubic metres per day. In addition, it manages 10,196 functioning deep (60 - 200m) tubewells with a diametre of 4 inches and a capacity of 467,000 cubic metres per day and 157 river pumps with a capacity of 1.55 million cubic metres per day. The river pumps are by nature located along the rivers, while the tubewells are spread more evenly over the areas (Figure 220).

The estimated areas irrigated in the Ayeyarwady Basin by groundwater (shallow and deep wells) and from pumping from rivers are presented in Table 54 and Table 55. Figure 219 shows the distribution of the groundwater irrigation as a percentage of the total area of groundwater irrigation in the Ayeyarwady Basin.

Table 54 - Groundwater irrigation from shallow and deep wells (ha, 2014)

(Calculated from WRUD and ICEM data)

State/region	Total	Area in the Ayeyarwady Basin	Percentage in the Ayeyarwady Basin	Area in hydro-ecological zones				
				Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Ayeyarwady	27,542	26,776	11	-	-	-	1,247	25,529
Bago (W)	3,382	3,224	1	-	-	-	2,049	1,175
Chin	-	-	-	-	-	-	-	-
Kachin	108	108	0.0	56	20	32	-	-
Magway	4,271	4,271	2	-	532	-	3,672	67
Mandalay	189,453	189,453	77	-	-	156,037	33,416	-
Sagaing	21,000	20,731	8	-	13,569	7,130	33	-
Shan (N)	81	64	0.0	-	3	61	-	-
Yangon	1,672	1,597	1	-	-	530	-	1,067
Total	247,509	246,225	100	56	14,124	163,790	40,417	27,838
Percentage			100	0	6	67	16	11

Table 55 - Pumped river irrigation (ha, 2014)

(Calculated from WRUD and ICEM data)

State/region	Total	Area in the Ayeyarwady Basin	Percentage in the Ayeyarwady Basin	Pumped irrigation areas in hydro-ecological zones (ha)				
				Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Ayeyarwady	16,037	14,424	16	-	-	-	666	13,758
Bago (W)	-	-	-	-	-	-	-	-
Chin	-	-	-	-	-	-	-	-
Kachin	-	-	-	-	-	-	-	-
Magway	34,847	26,363	30	1,446	3,016	92	21,809	-
Mandalay	48,326	35,363	40	-	11	28,350	7,002	-
Sagaing	-	-	-	-	-	-	-	-
Shan (N)	-	-	-	-	-	-	-	-
Yangon	13,337	12,707	14	-	-	5	-	12,703

State/region	Total	Area in the Ayeyarwady Basin	Percentage in the Ayeyarwady Basin	Pumped irrigation areas in hydro-ecological zones (ha)				
				Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Total	112,547	88,857	100	1,446	3,027	28,447	29,476	26,461
Percentage	-	-	100	2	3	32	33	30

These tables show that the CDZ regions Mandalay region, Sagaing region, and Magway region have received the largest shares in the development of groundwater and pumped river irrigation development. In Figure 217, the areas with pumped irrigation are shown as a percentage of the total area fitted with pumped irrigation.

The WRUD has 13 ongoing and planned river pump irrigation projects, 12 of which are in states/regions with areas in the Ayeyarwady Basin. The distribution over the Ayeyarwady Basin is shown in Table 56. Most of these projects are located in the Middle Ayeyarwady and the Delta.

Table 56 - Ongoing and planned pumped river irrigation (ha)

(Calculated from WRUD and ICEM data)

State/region	Total	Area in the Ayeyarwady Basin	Percentage In Ayeyarwady Basin	Ongoing and planned pumped irrigation areas in hydro-ecological zones (ha)				
				Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Ayeyarwady	11,331	11,016	23	-	-	-	513	10,503
Bago (W)	-	-	-	-	-	-	-	-
Chin	-	-	-	-	-	-	-	-
Kachin	202	202	0	105	38	60	-	-
Magway	3,845	3,844	8	-	479	-	3,305	60
Mandalay	20,457	20,457	43	-	-	16,849	3,608	-
Sagaing	-	-	-	-	-	-	-	-
Shan (N)	-	-	-	-	-	-	-	-
Yangon	13,047	12,463	26	-	-	4,136	-	8,327
Total	48,882	47,983	100	105	517	21,045	7,427	18,890
Percentage	-	-	100	0.2	1.1	43.9	15.5	39.4

Likewise, the WRUD has ongoing and planned groundwater irrigation projects with 8,413 tubewells in the states/regions of the Ayeyarwady Basin. The distribution of the groundwater irrigated areas over the Ayeyarwady Basin is shown in Table 57. Most of these tubewells are located in the Middle and Lower Ayeyarwady.

Table 57 - Ongoing and planned groundwater irrigation (ha)

(Calculated from WRUD and ICEM data)

State/region	Total	Area in Ayeyarwady Basin	Percentage In Ayeyarwady Basin	Ongoing and planned groundwater irrigation areas in hydro-ecological zones (ha)				
				Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Ayeyarwady	2,469	2,400	7	-	-	-	112	2,288
Bago (W)	-	-	-	-	-	-	-	-
Chin	-	-	-	-	-	-	-	-
Kachin	93	93	0	48	17	28	-	-
Magway	81	81	0	-	10	-	70	1
Mandalay	31,371	31,371	92	-	-	25,838	5,533	-
Sagaing	233	230	1	-	150	79	0	-
Shan (N)	-	-	-	-	-	-	-	-
Yangon	-	-	-	-	-	-	-	-
Total	34,247	34,175	100	48	178	25,945	5,715	2,289
Percentage	-	-	100	0.1	0.5	75.9	16.7	6.7

Almost all irrigation projects supply water mostly for paddy production and only a small amount of water is supplied to other crops such as pulses and oil seed crops. Because water pumping with diesel power is more expensive than with electricity, many river pumps and tubewells run on electric power. Unfortunately, the power supply in rural areas is not very dependable, and therefore irrigation supply is erratic. In addition, river pump intakes are mounted on floating platforms, which are vulnerable due to the wild nature of the Myanmar rivers.

c) Water tax

Farmers pay water taxes to WRUD for irrigation water depending on the source, type of supply, crop, and season as is indicated in Table 58. These water taxes are very modest (US$ 2 - 22/ha) and do not cover the real costs of this service, which are estimated by IWMI to be in the order of MMK 250,000/ha (US$ 187/ha). These real costs are charged by commercial water suppliers and include the annualized fixed cost of capital, plus operations and maintenance; they are affordable for high value crops and paddy with yields exceeding 4 t/ha. Irrigation services provided by WRUD are heavily subsidized by government and are run at a loss.

Table 58 - WRUD water taxes for irrigation (MMK/ha)

(Calculated from WRUD data)

Season/crop	Water tax (MMK/ha)			
	River pumping electric	River pumping diesel	Groundwater electric	Gravity
Summer paddy	22,500	30,000	22,500	4,875
Monsoon paddy	15,000	20,000	15,000	4,875
Other crops	7,500	10,000	7,500	2,250

For areas protected from flood with embankments and provided with drainage constructed and maintained by the state, farmers pay embankment taxes at the rate of MMK 12.5/ha. In 2015/2016, IWUMD collected MMK 3,519 million in water taxes and MMK 12 million in embankment taxes.

d) Fresh water withdrawal and water productivity

Fresh water withdrawal in Myanmar increased from 28 km³ in 1987 to 33 km³ in 2002 and remained stable to 2014. Trends in fresh water withdrawal in Myanmar, Bangladesh, Cambodia, Thailand, and Vietnam are depicted in Figure 51.

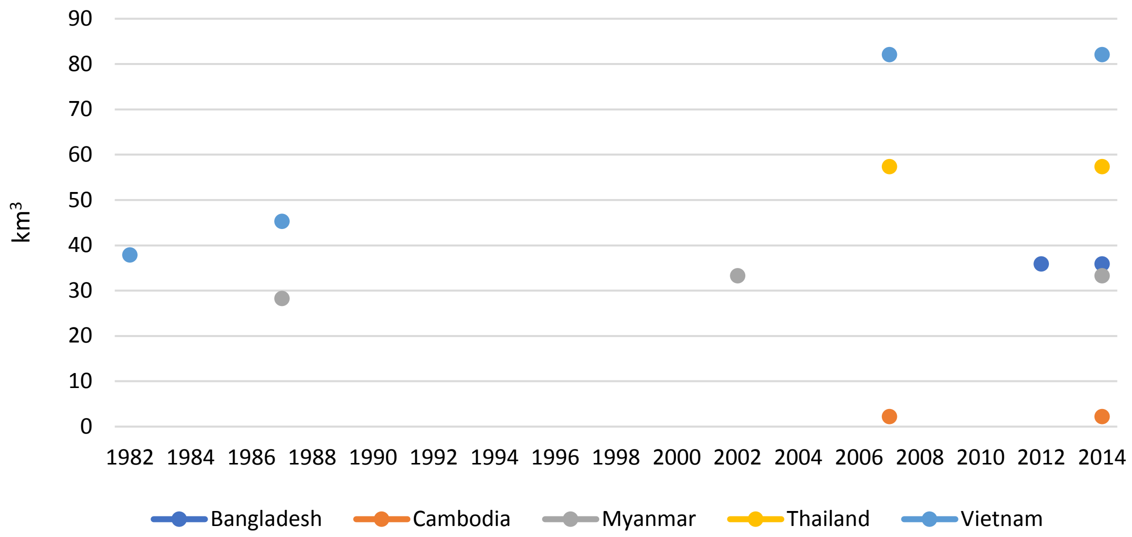


Figure 53 - Fresh water withdrawal

(World Bank 2017b)

Water productivity at the national level is expressed as GDP (in constant 2010 US$) divided by the total fresh water withdrawal. For Myanmar, Bangladesh, Cambodia, Thailand, and Vietnam these values are presented in Figure 54, showing that water productivity in Myanmar is similar to Vietnam, but much lower than Thailand and Cambodia. In 2014 the water productivity in Myanmar was US$ 1.98 per m³ fresh water withdrawal.

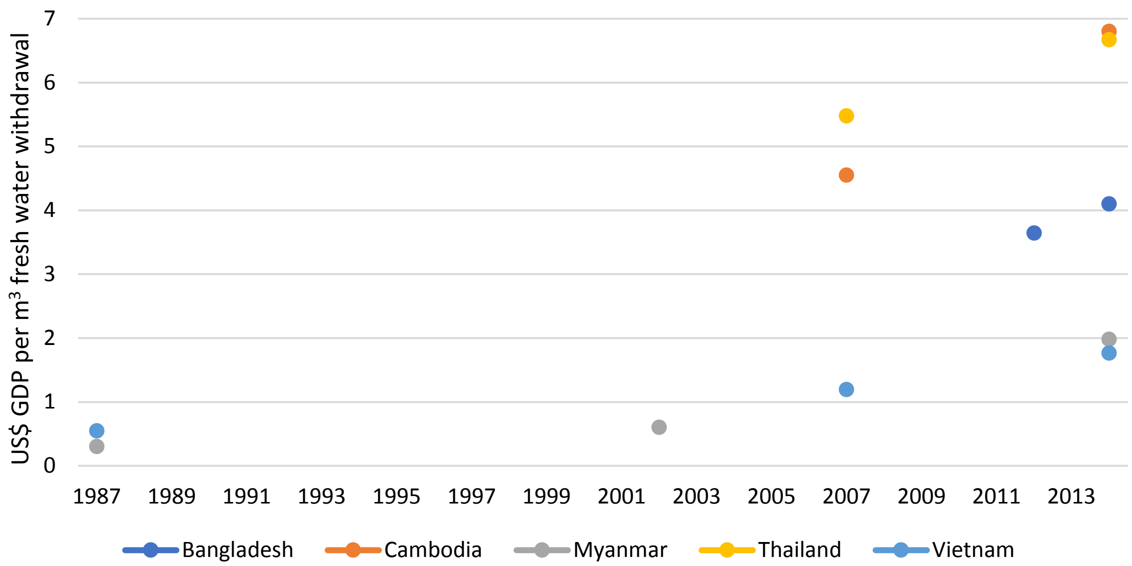


Figure 54 - Water productivity

(World Bank 2017b)

5.6.2 *Flood protection, drainage, and salinity control of agricultural areas*

a) Flooding in agricultural areas

Flooding in the Chindwin River Basin occurs as a result of intense heavy rain due to pronounced monsoon persisting for at least three days over the Northern Myanmar areas, and heavy rainfall due to cyclonic storm crossing the Myanmar and Bangladesh coasts during pre-monsoon and post-monsoon times. More detailed analysis of flooding extent and flood impacts are included in the technical reports for State of the Basin 1: Hydrology (SOBA 1) and State of the Basin 5.1 (Activity 4): Economic Valuation of Ecosystem Services in the Ayeyarwady Basin (SOBA 5.1). According to the Director of the Hydrological Division in the Department of Meteorology and Hydrology in Myanmar, flood risk management is hampered by:

- Lack of instruments for real time data observation such as rainfall and water level;
- Lack of real time data for utilization of flood forecasting ;
- No mobile Doppler Radar;
- Lack of communication system;
- No information from dam, reservoir, weir, etc.;
- Lack of coordination among government organizations;
- Insufficient flood related data and network;
- No automatic flood related data collection network;
- Insufficient knowledge about flood hydrology (rainfall runoff estimation, flood volume estimation, flood routing, etc.) in flood related departments;
- Lack of developing the early warning system for dangerous hydro meteorological phenomena; and
- Lack of flood risk maps.

In terms of riverine flooding, care needs to be taken to fully analyze the costs and benefits of flood dykes and other infrastructure. Floods provide many benefits for rural households, such as replenishing floodplain soils and supporting fish recruitment. Dykes are expensive to build and maintain. This sort of water infrastructure often has perverse impacts, for example, increasing flooding and erosion elsewhere. Similarly, a more detailed assessment is needed of any proposal to build dykes in the Delta against seawater intrusion.

In the Vietnamese Mekong Delta the yearly overland flow and flood-facilitating dikes support the safe harvest of the second rice crop, but allow flooding afterwards in the deep-flooded areas. More recently some of the deep-flooded areas have been fitted with full flood control, enabling the cultivation of three rice crops per year. This causes indeed more flooding elsewhere, limits the fish production, excludes the fertile silt from reaching the fields, and excludes the annual drowning of rats and cleaning of the soils from acids and pesticides. Moreover, expensive pumping is required to keep the areas dry during the flood season. The economics of full flood protection in deep-flooded areas is questionable. Before such investments are made in Myanmar, a full analysis should be undertaken.

b) Protection of coastal areas

The coastal areas of the Ayeyarwady Basin are abundant with coral reefs, mangroves, seagrass beds, mudflats, estuaries, and sand dunes that play an important role in the people’s socioeconomic development and environmental diversity. More specifically, they are vital for the development of the agricultural, forestry, fishery, and tourism sectors. Mangroves are an important asset in dealing with global climate change. They are being damaged by people clearing areas of mangrove forests for prawn breeding, using explosives for catching fish, mining, waste disposal, and oil spills. Deforestation also decreases the layers of alluvial soil along the coast. As areas of mangrove forests cleared for prawn breeding and rice plantation have decreased production after a certain period, farmers and breeders move to new areas and cut down more mangroves, thus leaving behind barren areas of land. There is a recognized need to establish forest reserves in the country’s coastal areas as they play an important role in controlling climate change.

5.7 Aquaculture in the Ayeyarwady Basin

Myanmar is a rice-fish culture, where rice provides the majority of energy in the diet (see Section 5.4.2), and fish provides a major share of micro-nutrients. Ensuring adequate availability of and access to fish supplies is therefore critical to ensuring food and nutrition security in a country where one out of every three children are stunted and one out of four are underweight (UNICEF, 2012). In the Ayeyarwady Basin aquaculture is carried out in fish ponds (fresh water) and shrimp ponds (brackish/salt water). Fish ponds are found in all states/regions, but mainly in Ayeyarwady and Yangon, whereas shrimp ponds are only located in the Delta in the Ayeyarwady and Yangon regions. A more comprehensive description of the aquaculture sector in the Ayeyarwady Basin is provided by SOBA 4: A brief review of the aquaculture sector in the Ayeyarwady Basin.

5.8 Livestock in the Ayeyarwady Basin

5.8.1 National overview

Livestock play an important role in the lives of many people in Myanmar in terms of livelihood, employment, food security and nutrition, and draught power for crop cultivation and rural transport. Livestock manure also provides a large amount of natural fertilizer for crops and horticulture. Livestock are regarded as a financial reserve. All male cattle, both sexes of buffaloes above three years old and less than 1% of cows are used as working draft animals. Livestock is generally more resilient to environmental risk than crops. They are mobile, which increases survivability and may also be relatively omnivorous, and thereby able to survive dramatic effects on specific feed resources. Native animal varieties in particular are adapted to local environmental risks and use natural resources efficiently. Finally, the provision of food, e.g., milk and eggs, from livestock provides nutritional insurance to households.

Small-scale family poultry production is practiced by most rural households throughout the developing world, and can also be found in peri-urban and urban environments. Small semi-scavenging flocks of indigenous birds and backyard poultry provide scarce animal protein in the form of meat and eggs, and are sold or bartered to meet essential family needs. They are generally owned and managed by women and children, and are often essential to women's incomes and their position within their households. Poultry plays important social and cultural roles in the lives of rural people, not least in building social relations with other villagers. The output of village poultry is lower than that from intensively raised poultry in commercial production systems, but it is obtained with minimum inputs in terms of housing, disease control, management and supplementary feeding. Village poultry have many advantages in mixed farming systems as they are small, reproduce easily, do not need large investments, and can scavenge for food. Chickens are the most common species, but mixed flocks including species such as ducks, geese, turkeys, or guinea fowls are also found.

Livestock, dairy, sheep/goat, and pig products provide an example of high-value agricultural produce. With roughly three out of four agricultural households already keeping livestock, they represent an important means for poverty reduction. Livestock have a variety of characteristics that make them important contributors to sustainable rural development. They provide marketable products that can be produced by small-scale, household production systems, and are generally of higher value and less vulnerable to critical harvest timing than many crops. As an agricultural product with relatively high-income elasticity, livestock are particularly attractive as a means for rural households to participate in urban-based economic growth.

Livestock are also productive assets, which contribute directly to farm output through animal traction and indirectly as a store of wealth for future investment. Finally, they can contribute to soil fertility and recycling of agricultural waste (Myanmar Census of Agriculture, 2010).

5.8.2 Livestock in the Ayeyarwady Basin

Cattle and poultry are the most common animals kept in the Ayeyarwady Basin. In Table 59 the number of animals per kind are presented, along with their distribution over the five HEZ of the Ayeyarwady Basin.

Table 59 - Livestock population in the Ayeyarwady Basin and their distribution over the hydro-ecological zones, 2010

(Calculated from Myanmar Census of Agriculture 2010 and ICEM data)

Animals	Animals in the Ayeyarwady Basin	Percent of animals in hydro-ecological zones				
		Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Cattle	8,833,109	203,191	1,955,483	2,879,944	2,323,804	1,470,686

Animals	Animals in the Ayeyarwady Basin	Percent of animals in hydro-ecological zones				
		Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Buffalos	911,704	71,306	188,368	365,431	59,044	227,555
Sheep/goats	1,194,964	6,592	195,147	521,019	421,212	50,994
Pigs	1,954,323	98,825	356,534	561,996	322,166	614,803
Poultry	24,079,902	710,098	3,598,875	6,509,927	4,766,861	8,494,141
Ducks	2,688,873	10,899	23,616	317,508	157,882	2,178,969

In Table 60 the livestock density (animals/km²) are presented, showing that the highest density of cattle and poultry is in the lower Ayeyarwady and especially in the Delta.

Table 60 - Livestock density in Ayeyarwady Basin hydro-ecological zones (animals/km², 2010)

(Calculated from Myanmar Census of Agriculture 2010 and ICEM data)

Animals	Animals in the Ayeyarwady Basin	Animal density in hydro-ecological zones (animals/km²)				
		Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Cattle	8,833,109	4.4	20.1	22.5	40.8	33.4
Buffalos	911,704	1.6	1.9	2.8	1.0	5.2
Sheep/goats	1,194,964	0.1	2.0	4.1	7.4	1.2
Pigs	1,954,323	2.1	3.7	4.4	5.7	14.0
Poultry	24,079,902	15.4	37.0	50.8	83.7	193.2
Ducks	2,688,873	0.2	0.2	2.5	2.8	49.5

A method to calculate different types of animals is to multiply their number first with a LSU factor. The LSU factor is a reference unit which facilitates the aggregation of livestock from various species via the use of specific coefficients established on the basis of the nutritional or feed requirement of each type of animal. In Table 61 the LSUs per HEZ are presented along with the percentage distribution. The table shows that the Upper Ayeyarwady has few LSUs as compared with the other zones, while the Middle Ayeyarwady has 30% of all LSUs of the Ayeyarwady Basin.

Table 61 - LSUs in hydro-ecological zones, 2010

(Calculated from Myanmar Census of Agriculture 2010 and ICEM data, combined with http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:LSU)

Animals	LSU factor	LSUs in the Ayeyarwady Basin	LSUs in hydro-ecological zones				
			Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Cattle	1.00	8,833,109	203,191	1,955,483	2,879,944	2,323,804	1,470,686
Buffalos	1.00	911,704	71,306	188,368	365,431	59,044	227,555
Sheep/goats	0.10	119,496	659	19,515	52,102	42,121	5,099
Pigs	0.30	586,297	29,647	106,960	168,599	96,650	184,441
Poultry	0.01	240,799	7,101	35,989	65,099	47,669	84,941
Ducks	0.02	53,777	218	472	6,350	3,158	43,579
Total LSU		10,745,183	312,123	2,306,787	3,537,526	2,572,446	2,016,302
Percentage		100	3	21	33	24	19

In Table 62 the density of farm animals in the HEZ of the Ayeyarwady Basin in terms of LSUs per km² is presented, showing the highest densities in the Lower Ayeyarwady and the Delta. Cattle is by far the most prominent type of animal in all zones and buffaloes appear mainly in the Delta. Figure 221 shows the total livestock density presented per HEZ/state level.

Table 62 - LSUs density in hydro-ecological zones, LSU/km², 2010

(Calculated from Myanmar Census of Agriculture 2010 and ICEM data, combined with http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:LSU)

Animals	LSUs density in hydro-ecological zones (LSU/km²)				
	Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Cattle	3.697	14.088	15.119	30.225	33.098
Buffalos	0.823	1.467	2.275	0.905	5.057
Sheep/goats	0.037	0.150	0.281	0.509	0.119
Pigs	0.384	0.888	0.940	1.221	4.159
Poultry	0.104	0.282	0.316	0.611	1.999
Ducks	0.003	0.003	0.022	0.044	0.969
Total	5.0	16.9	19.0	33.5	45.4

5.9 Support Services[18]

5.9.1 Rural Finance

The financial service providers in rural Myanmar include commercial banks, unregulated money lenders, other unregulated providers, pawnshops, the Myanmar Agricultural Development Bank (MADB), unregulated agricultural input providers, cooperatives, microfinance institutions, and rice-specialized companies (Food and Agricultural Organisation of the United Nation [FAO], 2016).

Rural outreach is largely driven by the state-owned MADB, who serves approximately half of the estimated micro-clients, but it does not meet all demand in its core focus area of seasonal paddy. A significant number of small farmers cannot provide right-of-use documents and therefore are not eligible for such loans. Furthermore, MADB loans are often not disbursed in time to finance the necessary preparation for the planting season and loan repayment is due when the crop prices are at their lowest (immediately after harvest). Consequently, farmers are often forced to source additional credit, mostly from money lenders at high cost as an interim financing measure (FAO, 2016).

The limited reach of regulated financial infrastructure in Myanmar has resulted in significant dependence on unregulated and often informal infrastructure to meet risk mitigation needs, especially among the rural population. Due to existing supply constraints, consumers are reliant on informal credit which is expensive. The unregulated financial sector constitutes the largest source of borrowing.

Myanmar has a capital-constrained regulated retail financial sector. All financial institutions suffer from a capital constraint that limits their ability to extend credit. There is also lack of sustainable business models to serve rural areas. The public sector relies on subsidies while the private sector is not yet sustainable in rural areas as the cost of doing business is high. Under current circumstances rural outreach depends on access to subsidized funding. Current interest rate caps do not enable or incentivize formal microfinance institutions to enter into new and more challenging markets.

In line with government policy, the National Action Plan for Poverty Alleviation and Rural Development through Agriculture project is expected to improve rural financial services, inter alia for resource-poor and marginal farmers, especially those with small (usually fewer than 2 ha) landholdings, the landless who are dependent on livelihoods from farm labour, small businesses, livestock or subsistence fisheries, especially vulnerable FHH, and particularly vulnerable national ethnic groups (FAO, 2016).

A major challenge and critical production factor at the farm level is the provision of more and reasonably-priced credit, as well as the delivery of extension services (see below), so that credit can be put to good effect by borrowing farmers. Microfinance providers will continue to cover only those who have an asset base which gives a degree of assurance to the lending agency for recovery in case of default.

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[18] Rural electrification, water supply, and transport are considered in Chapter 4 on livelihoods, although we recognise their importance for the agricultural sector.

There is lack of responsive and sustainable institutional finance to provide rural households with permanent, reasonably priced, and accessible financial services for various needs. The rural market is largely dominated by an agricultural economy and low-income households that are perceived as high risks. Poor infrastructure and lower population density also result in higher transaction costs. Thus the overall penetration rate of microfinance remains low and the microfinance market is characterized by a high degree of portfolio concentration in and around major cities.

There is a need to identify an appropriate delivery mechanism that will contain the transaction costs, increase outreach and effectively target the rural poor and women. Community organizations may offer new avenues for microfinance. Village-level community organizations could evolve into more formal credit and savings organizations that could be provided with additional seed funding to extend lending, subject to regulatory issues being resolved and the introduction of appropriate systems and processes. The use of an experienced microfinance provider with an intensive emphasis on capacity development within community groups, considerably lessens the risks of poor financial management at the community level.

Seasonal crop loans and medium and long-term loans are provided by the MADB. Crop loans for paddy are now MMK 250,000/ha (US$ 186/ha). In 2014/2015 MADB provided seasonal loans with a total of 1.167 billion (US$ 872,850). The planted paddy area in that year was 7.172 million, hence the average loan per ha of paddy was only MMK 166/ha (US$ 0.12/ha), suggesting that there is ample scope for the increase of seasonal crops loans (FAO 2016).

5.9.2 Extension

The Department of Agriculture has an Agricultural Extension Division, employing 10,760 people, with approximately 5,600 in the Ayeyarwady Basin. The estimated distribution of these extension workers over the HEZ of the Ayeyarwady Basin is presented in Table 63. This table also lists the number of households (each household having on average 4.5 persons) per extension worker in the HEZ, showing that on average there is a worker for every 882 households; in the Delta there is only one worker per 1,120 households.

The department plans to use mobile phone applications to provide farmers with timely access to market information. They also plan to create a call centre for farmers to provide advisory services, thereby improving the efficiency of its extension workers. The newsletters of the department are available online.

Table 63 - Extension workers in hydro-ecological zones of the Ayeyarwady Basin

(Department of Agriculture, Myanmar Census of Agriculture 2010 and ICEM data, assuming an uniform distribution of extension workers within the states)

State/region	Extension workers	Percentage in state	Extension workers in the Ayeyarwady Basin	Extension workers in hydro-ecological zones				
				Upper Ayeyarwady	Chindwin	Middle Ayeyarwady	Lower Ayeyarwady	Delta
Ayeyarwady	921	9	895	-	-	-	42	854
Bago (W)	795	7	758	-	-	-	482	276
Chin	342	3	230	-	176	-	54	-
Kachin	277	3	277	143	51	82	-	-
Magway	1,070	10	1,070	-	133	-	920	17
Mandalay	1,016	9	1,016	-	-	837	179	-
Sagaing	1,335	12	1,318	-	863	453	2	-
Shan (N)	1,084	10	855	-	38	818	-	-
Yangon	525	5	502	-	-	166	-	335
HQ and other states	3,395	32	-	-	-	-	-	-
Total	10,760	100	6,921	143	1,261	2,357	1,679	1,482
Percentage	-	-	100	2	18	34	24	21
Households/worker	-	-	901	905	792	815	861	1,175

5.9.3 Crop insurance

A coordination meeting on the introduction of insurance services for farmers and fishers was held at the Union of Myanmar Federation of Chambers of Commerce and Industry in Yangon on 19 August 2017. According to the Myanmar Rice Federation, the Myanmar Insurance Business Supervisory Board has decided to resume the life-insurance system for farmers to benefit both the local agricultural sector and rural people.

The Myanmar Rice Federation is also making efforts to develop natural disaster insurance and crop insurance. Crop insurance has been approved in parliament. Moreover, Myanmar Insurance has discussed the introduction of a weather-based insurance system with Japan. The crop insurance system will be introduced following policy decisions by the government, the insurance supervisory board, and the Ministry of Planning and Finance. A weather based insurance system will be introduced first, and will then be extended for drought, floods, and then yields. A crop insurance system is expected to be launched in 2017. At present only the state-owned Myanmar Insurance can offer crop insurance, local, private insurance companies are currently unable to offer crop insurance services. One Japanese insurance company offers the service in the Thilawa Special Economic Zone. A Japanese insurance company has submitted a proposal to Myanmar Insurance to provide rainfall-based insurance services in Pyay and Shwebo townships.

5.10 Agricultural Policy Options

In the past, the government controlled the choices of crops. Farmers did not have freedom of choice to select crops. If the area was close to a sugar mill, for example, farmers had to grow sugarcane although it was not a profitable crop. Now, farmers have free choice in selection of crops. They can compare crops and select the most profitable without restriction. In addition, there are no restrictions on trade of agricultural commodities, and also no support prices for outputs or subsidies for inputs, except for government groundwater and lift irrigation (see Sub-section c).

Other countrie in the region have shown that, in response to consumer demand for increasingly diversified diets as incomes and urbanization rise, investing in rural infrastructure and establishing policies to encourage their farmers to produce products that meet market needs will unleash a virtuous circle of growth among farmers, food processers, and service providers who are linked to growing urban centres and export markets. Raising productivity and diversifying from low-value grains into high-value meats, oilseeds, pulses, horticulture, and aquaculture stabilizes food expenditures for increasingly urban consumers, raises incomes for rural areas, and strengthens competiveness in regional and global markets. Among Asian neighbours, it has helped raise millions of rural people out of hunger and poverty.

In its Vision for Myanmar's Agricultural Development, the National Economic and Social Advisory Council (2016) compares the agricultural development in Myanmar with the rest of Asia and formulates a vision to generate a more productive, responsive, and inclusive agricultural and food sector that is sustainable over time. Such an agricultural and food sector will generate jobs throughout the country, increase rural income and savings, stimulate investments in farms, rural small and medium-sized enterprises (SMEs), and people, resulting in a virtuous cycle that can pull millions out of poverty, while providing affordable, stable supplies of food with rising food security and nutrition for all. The following Implementing Principles are proposed:

Facilitated by government, driven by the private sector. Government provides the policies, institutions, and public infrastructure needed to enable farmers and the rest of the private sector along supply chains to invest, become more productive, and meet consumer demand.

Emphasis on smallholder farmers and SMEs. Focus will be on small farmers and SMEs as the core drivers of growth, equipped with inputs, technologies, and market information to make informed decisions about what is best for them to produce, enabled by investments from larger domestic and foreign-owned businesses, and overseen by strong, smart, supportive government institutions.

Transparency, participation, accountability, and ethics. These principles should govern the process of policy development, communication, stakeholder outreach, and the monitoring of implementation of those policies at all levels of government. Implementation of all policy processes should respect the highest ethical standards, enforced by strong anti-corruption measures.

Environmental and social sustainability. Agriculture and food production have environmental impacts, and the sector is affected by important environmental impacts from other sectors. Collective decisions must be made to balance needs for growth and income generation across the economy relative to short and long-term environmental and social impacts.

Systematic approach to agriculture and the agrifood sector. Agricultural and food sector modernization should encompass not only crop agriculture, livestock, and irrigation, but also fisheries and forestry/agro-forestry. The agriculture ministry also needs to consider not only production-level issues, but also broader issues of output markets and supply chains, including trade and business enabling environments. Success in one area requires balanced attention to the other two.

Intra-government coordination for improved policy-making and implementation. Coordination of policy-making and implementation among and within ministries, between government and parliament, and between Union and local authorities, avoiding traditional silos, is essential for best results.

New institutional structure, capacities, and responsibilities. Consolidation of the agriculture and livestock ministries provides a unique opportunity to re-think the full organizational structure of the newly integrated ministry. To be fully in line with the new Vision will require new departments or divisions, human resources, tools, and practices, and shifts in budgets to reflect new priorities.

Prices matter. Price analysis should be integral to the policy work of the new ministry, crucial as Myanmar transitions to greater reliance on supply and demand forces to allocate resources. This will require greater capacity to collect, analyse, and understand price signals, including understanding the impacts of exchange rates, tariffs and other trade interventions, elasticities of demand and supply, foreign market movements, and other factors on the incentives faced by all agrifood actors in Myanmar.

Monitoring the effectiveness of policy implementation enhances accountability. Given the new government's commitment to transparency and accountability, MOALI should develop indicators to quantify the impacts of investments and policy reforms on agrifood sector segments, on interest groups (landless, smallholder producers, rural non-farm enterprises, downstream supply chain actors, rural consumers, and food consumers), by state and region, and throughout the supply chain. This will ensure that policies are implemented effectively to achieve desired outcomes; if they are not, adjustments can be made to avoid waste and possible unintended consequences.

5.11 Conclusion

5.11.1 Key findings

The Ayeyarwady Basin has ample land and river water resources, but rainfall is unevenly distributed. In the dry areas irrigation is essential for crop production, but in the wet areas supplementary irrigation is needed to even out dry spells. Irrigation, along with flood protection in the coastal areas is therefore of vital importance to improve agricultural production for domestic food supply and export. There is still unused land available to extend the agricultural area and make up for the loss of agricultural land due to infrastructure development and urbanization. These lands, and much of the existing land, need improvement in access and electrification. River lift and groundwater pumping schemes are expensive and unreliable. With dedicated electric feeder lines this could be partly remediated. Agricultural support services, especially seed and credit, are limiting factors for the agricultural sector, as they need remediation, possibly in cooperation with the private sector. Further farm mechanization, especially for paddy harvesting, drying, and milling, are needed to reduce losses and improve quality. With improved quality more high-end foreign rice export markets will become available.

Despite the significant potential of agriculture in Myanmar and recent improvements in the sector, it lags well behind other countries in the region in terms of practically all performance metrics. Key issues identified include:

- Inadequate availability of inputs (quality seed, and fertilizer and pesticides);
- Inadequate water infrastructure to protect farmland from flooding and drought;
- Weak tenure rights (see Chapter 11);
- Limited government support for farmers (extension services, and low level of spending on agricultural research and development);
- Limited infrastructure provision (rural electricity, rural roads, and bridges);
- Limited access to timely and sufficient credit; and
- Limited availability of crop insurance.

a) Environmental issues in the agricultural sector

Given its close reliance on natural resources and its role in modifying natural systems to improve productivity, there are many significant environmental issues associated with activities in the agricultural sector:

- **Deforestation** - agricultural practices are heavily implicated in forest loss. Some assessments have suggested that swidden agriculture is the single largest cause of forest loss in Myanmar. Clearing trees for agribusiness plantations has also been a key cause of forest loss in recent years, including both intact forest and degraded forest (which is often part of swidden cycles). Upland areas are most affected by this such as the Bago Hills, Kachin State, Sagaing Region, Chin State, and Shan State. Deforestation due to agricultural encroachment may also be a problem in the coastal mangrove forests, which have also seen rapid declines over recent years;
- **Land degradation** (water erosion) - cultivation of steeply sloping land and higher intensity agricultural practices (the shortening of the swidden cycle in particular) has in some circumstances led to soil erosion. This degrades soils and causes increased sediment loads. In serious cases this can result in loss of slope stability and landslides, or the localized loss of soil altogether. This is a common problem throughout the country, and in hilly areas in particular.
- **Desertification** - deforestation, erosion (from water and wind), and salinization of soils in the Dry Zone contribute to desertification. Dry Zone soils are sensitive to degradation due to low natural levels of fertility, high salinity, low organic content, exposure to brief periods of intense rainfall, and overall low annual rainfall totals.
- **Salinization** (Dry Zone) - in Dry Zone areas salinization is associated with the evapotranspiration of saline groundwater or irrigation water leaving a salt crust on the soil surface. In Dry Zone areas this

can accumulate over years and rainfall can be insufficient to flush the salt concentration from the soil.

- **Salinization** (coastal areas) - in coastal areas salinization occurs due to 1) ingress of salt water in estuarine areas and up rivers, 2) storm surges and tides, and 3) infiltration via groundwater. This can be a problem for farmers during the dry season in coastal areas preventing the cultivation of some crops. This is the case in southern areas of the Ayeyarwady Delta from January onwards until the onset of the monsoon but it also likely affects other coastal areas such as the Sittaung Delta, and the coastal plains in Rakhine State and Tanintharyi.
- **Drought and irregular rainfall** - variability of rainfall and to a lesser extent droughts pose a problem for farmers in the Dry Zone. Variability in the onset of seasonal rainfall is a particular problem.
- **Flooding** - Myanmar is susceptible to seasonal flooding damaging agricultural infrastructure, crops and livestock. In upland areas and the narrow coastal plains of Rakhine State and Tanintharyi Region rapid onset flooding is a problem. This issue has probably been exasperated by continuing deforestation. Slower onset, riverine flooding can affect large areas to the north of the Ayeyarwady Delta as well as areas in the Dry Zone and the confluence of the Ayeyarwady and the Chindwin is particularly prone to flooding. Production is susceptible to flooding. Coastal areas are susceptible to flooding due to extreme weather events such as cyclones, in which intense rainfall is often combined with a storm-surge.
- **Water pollution** - while there is limited documentation of instances of water pollution and declines in water quality due to agricultural practices in Myanmar, as elsewhere in the region it is likely to be an increasingly important issue. Increasing agricultural intensity results in greater use of fertilizers and agricultural chemicals. More intensive livestock production results in high concentrations of animal waste entering waterbodies. Less sustainable cultivation practices lead to increased sedimentation; all are likely to affect water quality (ICEM, 2017).

b) Agricultural and associated environmental issues by river basin

The Ayeyarwady Basin is central to Myanmar's agricultural production. Importantly, the delta accounts for a large proportion of the county's rice, pulses, and oil crop production. Key issues for agriculture in the basin are varied. In the upper reaches of the catchment in Kachin state, Sagaing region, and some areas of Shan State, deforestation due to clearing for various agricultural activities is important. Related to this, increased incidence and intensity of agriculture on sloping land is a growing issue. Both deforestation and the expansion of agriculture on sloping land lead to erosion, land degradation, and flooding. Lower in the catchment in the Dry Zone, agricultural issues relate to variability in water availability and soil erosion. Riverine flooding is an important constraint on agriculture in some Dry Zone areas. The coastal and estuarine areas face issues of saline intrusion, as well as riverine and coastal flooding. These risks are increased through the loss of mangrove forest.

The Chindwin Sub-basin is dominated by forest cover and more intensive agriculture is practiced where conditions allow in valley bottoms and other flat areas, where wet rice and other crops can be cultivated. However, swidden agriculture dominates and much of the forest is already degraded. There is anecdotal evidence that swidden cycles have shortened in this river basin, and there is evidence of a change to sedentary agriculture, for example through the development of terrace systems in Chin State. Key issues are likely to be rapid onset flooding, a lack of infrastructure to support agriculture (such as roads and irrigation infrastructure), and continuing forest degradation and loss. Landslides and soil erosion are also likely to be issues in hilly areas of the basin.

5.11.2 Development options

The following development options have been identified:

- **Develop VFV lands for agriculture**. In the Ayeyarwady Basin there are 8 million ha of unused land, especially in the Chindwin and Middle Ayeyarwady.
- **Improve mechanization of paddy harvesting, milling and storage**. Quantity and quality losses in rice production can be much improved with better harvesting, milling, and storage.

- **Improve irrigation in areas equipped for irrigation**. Some 30% of lands in the command areas of surface irrigations schemes cannot be irrigated because of lack of distribution systems and land consolidation in some 200,000 ha.
- **Improve the reliability of river- and groundwater pumping schemes by improving power supply.** The reliability of these existing and planned pumps can be improved with dedicated power lines. Once reliable, water taxes, which currently do not cover the pumping costs, could be increased.
- **Increase double and triple paddy cropping in areas already equipped for surface irrigation**. Currently rainfed single cropping is the dominant copping system in the Ayeyarwady Basin. Irrigated double (3.9%) and triple (0.5%) cropping could be increased in areas already equipped for surface irrigation for cultivation in the dry season. Rice produced in this season has higher yields (more sunshine) and better quality (less fungus).
- **Speed up land certification**. Under the 2012 Farmland Law farmers can obtain land certificates that allow them to sell, mortgage, lease, exchange, and give whole or part of the rights to use the farmland in accordance with the stipulated terms and conditions by registering the transferable deed. The process to obtain these new certificates needs speeding up, as still many farmers do not avail them.
- **Improve supply of quality paddy seed.** The supply of quality seed, especially for paddy remains problematic, as only 50% of the used seed is certified. MOALI has insufficient capacity and may seek to intensify the cooperation with the private sector to improve the supply.
- **Increase of agricultural loans**. The provision of seasonal crop loans by the MADB to date only can meet a tiny fraction of the demand. Crop loans, and medium-term loans for machinery, are essential to modernize Myanmar's agricultural sector.
- **Increase electrification of villages**. Currently only approximately half of the 63,899 villages in Myanmar have access to electric power. To keep villages attractive for young people and to modernize agro-processing and animal husbandry, electric power is essential.
- **Improve rural road network**. Like electricity, rural roads are essential to connect villages to the modern world in order to create affordable access to farm inputs and to sell output.

6 FORESTRY

6.1 Introduction

Myanmar has significant forest resources. While figures differ between sources, the United Nations Food and Agriculture Organization (FAO) suggests that in 2015 approximately 44.5% (290,000 km²) of the land area of Myanmar (676,000 km²) was forested. Myanmar's notable forest resources include more than half of the world's remaining teak (*Tectona grandis*) and other valuable hardwoods. Natural teak forests are a particularly precious resource that produce good-quality logs that sell at comparatively high prices. The main forest types in Myanmar are shown below in Table 64.

Table 64 - Main forest types in Myanmar

(FD, 2015)

Forest types	Area (ha)	% of total forest area
Mangrove forest	467,330	1.47
Hill and temperate evergreen forest	8,541,190	26.88
Tropical evergreen forest	5,470,600	17.22
Mixed deciduous forest	12,157,300	38.26
Deciduous Indaing (Dipterocarp) forest	1,321,870	4.16
Dry forest	3,114,710	9.80
Scrub land	700,000	2.20

Despite the significant remaining extent of its forested area, Myanmar is experiencing rapid rates of deforestation. Myanmar has the third highest deforestation rate in the world, behind Indonesia and Brazil, and has lost more than 54,600 km² of forest each year since 2010 (FAO, 2015). Between 1990 and 2015 Myanmar saw forest cover decline by approximately 26%, from approximately 392,000 km² to 290,000 km² - an average of 6,785 km² a year (Figure 55). Findings suggest there has been a significant increase in the rate of deforestation over the last five years (International Finance Corporation [IFC] et al., 2017).

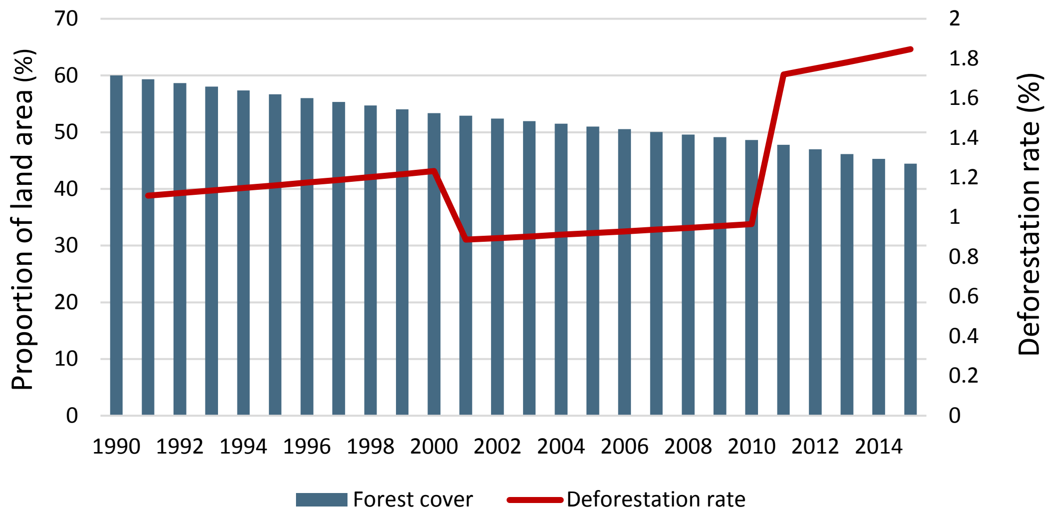


Figure 55 - Forest cover in Myanmar 1990 - 2015 and deforestation rate 1991 – 2015

(World Bank, 2017b)

The Ayeyarwady Basin has areas of closed (or intact) forest and is experiencing relatively high rates of deforestation, forest cover, and land use change shown below (Figure 56).

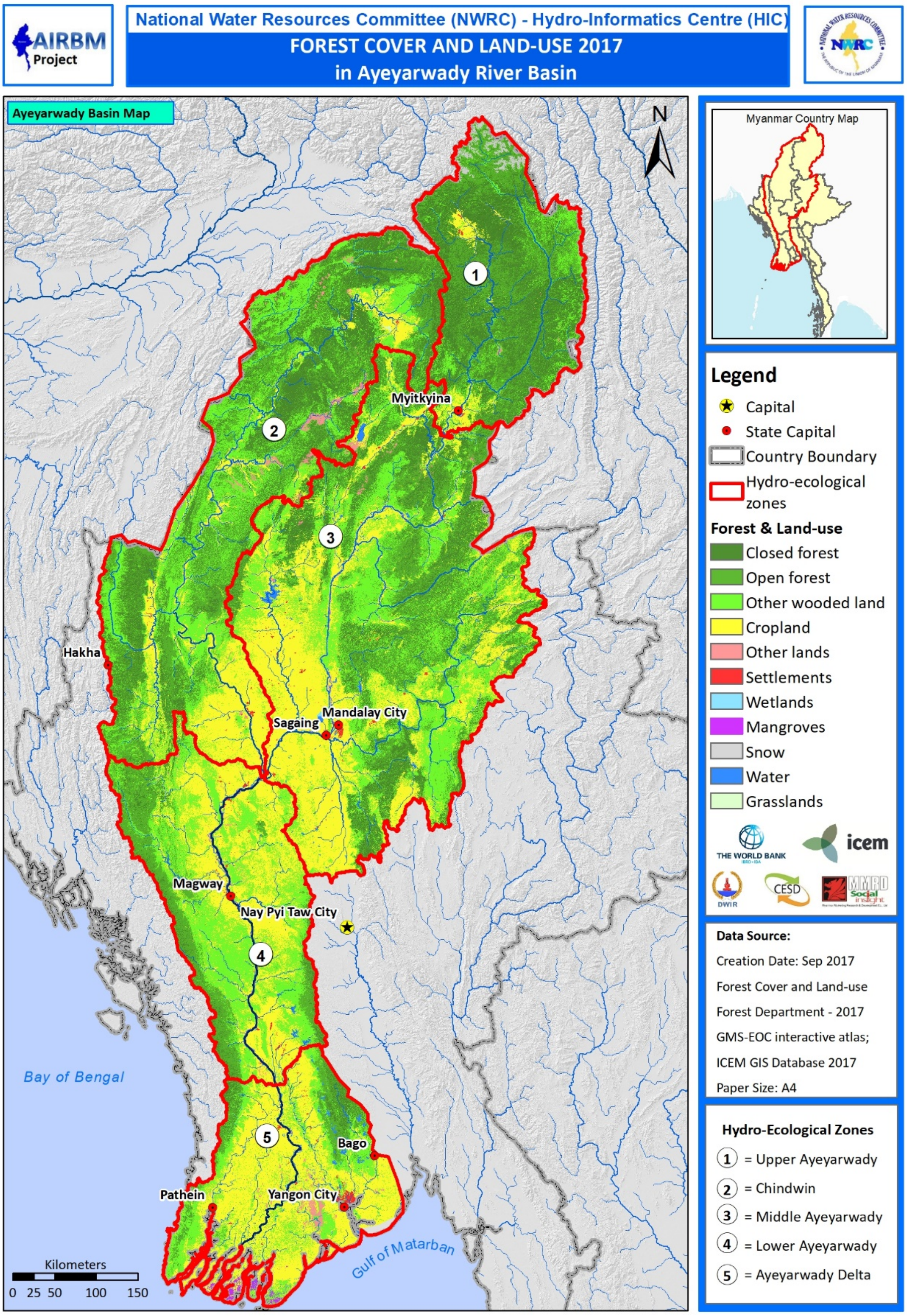


Figure 56 - Forest cover and land use in the Ayeyarwady Basin

(FD, 2015)

Table 136 in the Annex provides a detailed breakdown of the 11 forest cover and land use categories used by the FD for each of the HEZs and states/regions in the Ayeyarwady Basin. In summary:

- 40.8% of closed forest (26,395.5 km^2) remains in the Upper Ayeyarwady HEZ (closed forest has high canopy cover and is also referred to as intact forest);
- 33% of open forest (26,577.5 km^2) is in the Upper Ayeyarwady HEZ and 31% (25,340.6 km^2) is in the Chindwin HEZ; and
- 36% (39,554.2 km^2) of cropland is in the Middle Ayeyarwady HEZ and 24% (25,925.6 km^2) in the Ayeyarwady Delta.

Analysis is provided on forest loss (Section 6.2) and timber production (Section 6.3) in the Ayeyarwady Basin. The Ayeyarwady Basin cuts across many administrative boundaries, however for the purpose of this analysis the following states/regions were used when spatial or township level data was not available: Ayeyarwady region, Bago region, Chin state, Kachin state, Magway region, Mandalay region, Sagaing region, Shan state, and Yangon region.

6.1.1 Institutional

Recent policy reforms in the forestry sector include logging bans to address rapid deforestation and forest degradation. It is important to understand these policy drivers when assessing the forest section in the Ayeyarwady Basin. Currently, the following laws, rules, and codes of practice are used for the management and protection of forests in Myanmar:

- Forest Law 1992 & Rules 1995
- Protection of Wildlife & Wild Plants & Conservation of Natural Areas Law 1994 & Rules 2002
- Environmental Conservation Law 2012 and Rules 2014
- Community Forestry Instructions 1995
- Myanmar Timber Enterprise (MTE) Extraction Manual 1948
- State Timber Board Act 1950
- Standing orders for Extraction Staff of MTE 1970
- Logging Rules 1936
- National Code of Forest Harvesting Practices 2000

The GoM has committed to implementing a 30-year National Forest Master Plan (2002 - 2031) which includes 10-year district management plans, a 5-year action plan and annual work plans. The master plan sets goals of achieving:

- 30% of the land area being within the permanent forest estate; and
- 10% of the land area being within protected areas by the year 2030.

Currently more than 200,000 km^2 or 31% of the total land area is designated within the PFE. The PFE is under the authority of FD and there are three different legal classifications used for the management of forests:

- **Reserved Forest (RF)** - areas of forest reserved by the government as they contain high value timber. These account for 119,686 km^2 or 17.8% of total land area.
- **Protected Public Forests (PPF)** - lower value timber usually for domestic supply. These account for 47,422 km^2 or 6.95% of total land area.
- **Protected Area System (PAS)** - these account for 38,880 km^2 or 5.75% of total land area.

'Unclassified forest' (or wasteland) is an additional category. These are forested areas that are managed by MOALI and account for approximately 38,809 km^2 or 4.4% of total land area.

Given that 54% of the country's greenhouse gas emissions come from the forestry sector, Myanmar has made a number of global commitments to reduce deforestation and forest degradation. In 2011, Myanmar joined the UN-REDD Programme (United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) and completed a REDD+ Readiness

Roadmap June 2013. In 2014, Myanmar also expressed interest in negotiating a Voluntary Partnership Agreement with the European Union (EU) under the Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan (Kissinger, 2017).

Myanmar submitted its Intended Nationally Determined Contributions to the United Nations Framework Convention on Climate Change in 2015. To ensure they can be implemented, Myanmar reiterated its commitment to increase RF and PPF to 30% of total land area by 2030 (up from 24.5%), and 10% of the land within the Protected Area System. This reinforces a previous commitment under the Convention on Biological Diversity (CBD). These goals were again reiterated in the National Biodiversity Strategic Action Plan (NBSAP) 2015.

The Government of Myanmar has also introduced a number of key policy measures to tackle illegal logging and deforestation. These include:

- **2006** - bilateral agreement between Myanmar and the People's Republic of China (PRC) to stop illegal cross-border timber trafficking across their shared border;
- **2014** - the raw log export ban for teak and hardwood;
- **2016/2017** - logging ban was introduced as part of the NLD 100-day plan; and
- **2016/2017** - 10-year logging ban in the Pegu Yoma Region.

While they are still in their early days, these policy reforms have achieved some success in reducing extraction of teak and hardwood logs and increasing the area of plantations and the local distribution of timber (Figure 57).

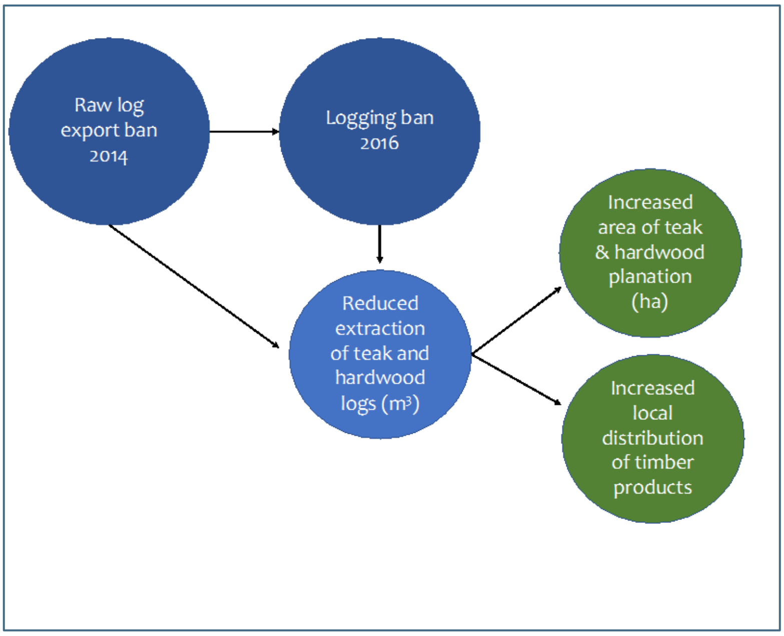


Figure 57 - Policy reforms and impact in the forestry sector

These are important steps to address deforestation; this report will further analyse the impacts of these policy measures on timber harvesting, illegal logging, timber plantation, and the value of teak and hardwoods.

6.2 Forest Cover and Forest Loss

From 2010 to 2015, Myanmar had the third largest forest loss in the world. This was equivalent to an annual loss of 5,460 km^2, or a rate of 1.7% per year (FAO, 2015). This section will assess the extent and impacts of forest loss and forest degradation in the Ayeyarwady Basin, which can be defined as:

- **Deforestation** - commercial agriculture, subsistence agriculture, mining, infrastructure, and urban expansion; and

- **Forest degradation** - logging, fires, livestock grazing in forest, fuelwood collection, and charcoal production.

Forest loss not only presents concerns for the long-term sustainability of the sector itself, but also entails broader environmental consequences, including land degradation, erosion and soil loss, sedimentation, increased flooding, loss of biodiversity, and local and global climatic change. As the quality of the forest declines, the carbon stocks of the forest are reduced (Kissinger, 2017).

The data from the FAO Forest Resource Assessment 2015 indicates a drop in closed (or intact) forest, while 'other lands' increased significantly over the last 10 years. This points to conversion of forest to other land uses, i.e., mining and agriculture. Further analysis is needed to determine how approximately 50,000 km^2 of closed forest is now categorized as 'other land' and how this will impact on future forest management (Kissigner, 2017). The declining trend is especially apparent for closed forests, which have decreased from covering 45.6% of land in 1990 as the single largest land use, to just 19.9% in 2010 (Tint et al., 2011). For the analysis of forest loss in the Ayeyarwady Basin this report will refer to three recent studies:

- Global Forest Resource Assessment 2015 (FAO, 2015);
- Myanmar Forest Cover Change (2002 - 2014) study (Bhagwat et al., 2017), data available from ftp://glcf.umd.edu/glcf/Myanmar_ForestChange; and
- High-Resolution Global Maps of 21st-Century Forest Cover Change (Hansen et al., 2013), data available from http://earthenginepartners.appspot.com/science-2013-global-forest.

These studies all use GIS analysis to identify similar trends, but use different methodology and classifications for forest types, forest cover, and forest loss or degradation. Table 137 and Table 138 in the Annex summarise the data for the HEZ and states/regions of the Ayeyarwady Basin.

6.2.1 *Forest loss in the Ayeyarwady Basin*

Deforestation and degradation of existing forests remain a critical issue in Kachin State and Sagaing Region in the Ayeyarwady Basin. This is mainly due to illegal and legal timber extraction, which is facilitated through the development of areas cleared for plantation and extensive mining activities. Other states and regions in the Ayeyarwady Basin, particularly Shan State, have seen more moderate levels of forest loss. Beyond the expansion of plantations and agriculture, the continued over-exploitation for fuelwood and charcoal also drives forest loss. In the delta, deforestation has been driven not only by the development of plantations but also the use of forests for fuelwood and aquaculture construction (IFC et al., 2017).

The rates of change between forests and non-forest are quite different at the subnational level. The latest FD data for States and Regions in the Ayeyarwady Basin reported that the Ayeyarwady and Mandalay experienced the highest rates of deforestation, while Yangon, Bago, Kachin, and Shan states experience the least deforestation, based on percentages (Kissinger, 2017). However, other forest cover assessments contain vastly different findings for Kachin and Shan states. Bhagwat et al. (2017) highlighted that most of the intact forests are concentrated in the hilly and mountainous regions of the Kachin state, Sagaing region, Shan state and Chin state and significant forest loss is occurring in these areas (**Figure 58**). These remote areas contain very large remaining tracts of intact forest but have experienced forest loss, usually along major river systems, newly constructed highways, or near existing development areas. The remaining areas of intact forest in northern Sagaing Region and Kachin state are also recognised as key biodiversity areas (NBSAP, 2015).

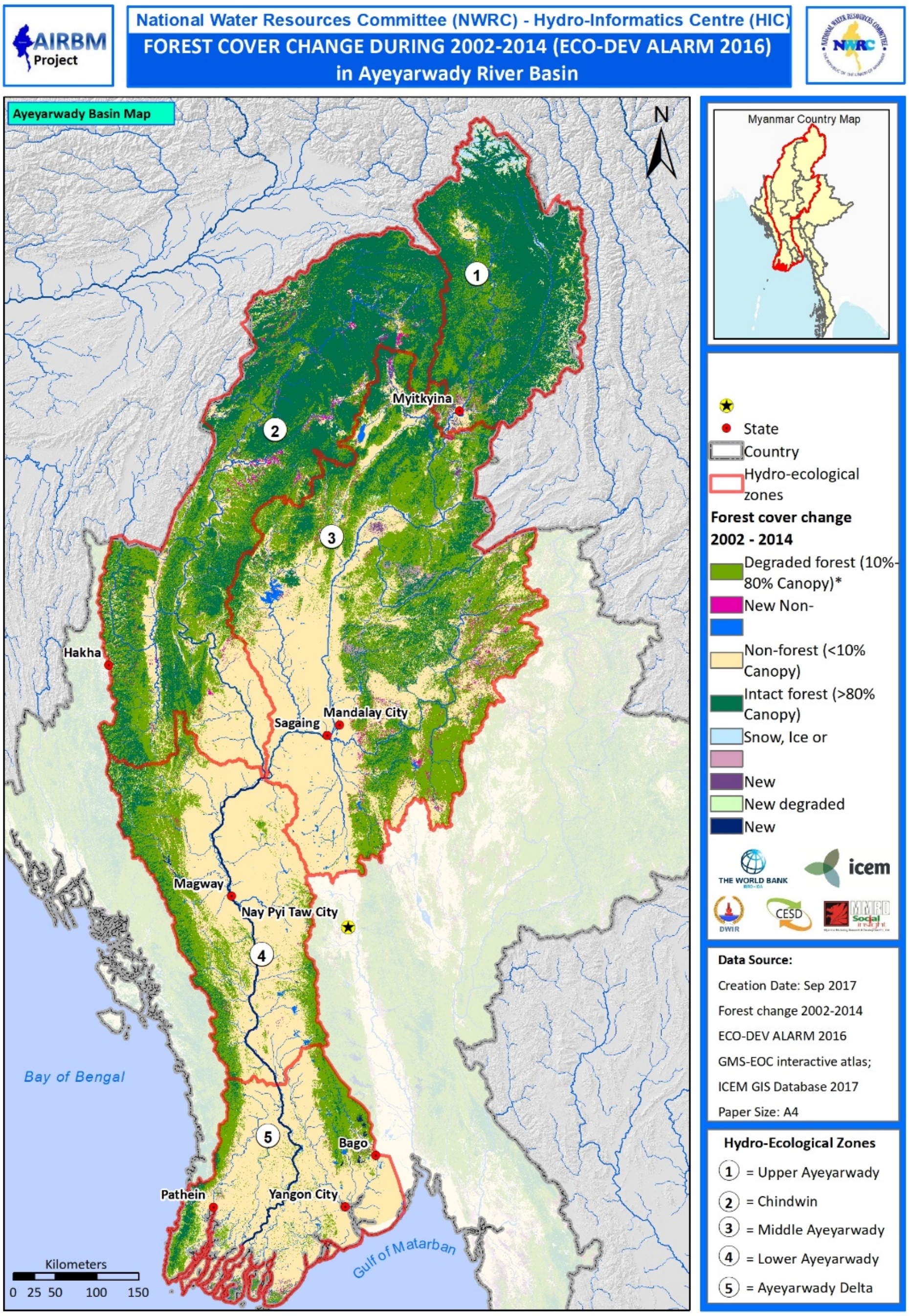


Figure 58 - Forest cover change from 2002 - 2014

The Myanmar Forest Cover Change (2002 - 2014) study reported more than 20,000 km² of forest loss came from intact forest in Myanmar, which reduced these valuable ecosystems by more than 11% with an annual net loss of 0.94% (IFC et al., 2017). The largest losses of intact forest in the states/regions of the Ayeyarwady Basin were reported in Shan state(6,326 km² or 26%), Sagaing region(2,798 km² or 8%), and Kachin state (2,090 km² or 4%), and areas with the largest remaining intact forest are in Kachin (51,234 km²), Chin state(13,384 km²), and Sagaing region(31,916 km²; Bhagwat et al., 2017). The main drivers of forest loss in the Ayeyarwady Basin were attributed to conversion to:

- Degraded forests resulting from overuse for logging, fuelwood consumption, and shifting cultivation (47,000 km²);
- Plantation crops such as oil palm, rubber, and sugar cane (5,400 km²);
- Existing HP dams and reservoirs (~700 km²); and

- Other non-forest land uses such as mining, clear-cutting for agriculture, and infrastructure.

In the Ayeyarwady Basin, it was estimated that Shan state and Sagaing region experienced the highest overall losses in intact forest, likely due to the forests already being quite fragmented. Declines are also noted in high and more remote and inaccessible areas such as Kachin state, and in other hill regions in Chin state and Bago region. Large areas of intact forest have been converted to agricultural plantations and lost to mining, particularly in Sagaing Region. Table 65 below provides a summary of the estimated intact forest loss and drivers for the states/regions in the Ayeyarwady Basin.

Table 65 - Summary of intact forest loss between 2002-2014 and drivers in Ayeyarwady Basin state/regions

(Modified from Bhagwat et., al 2017)

State/region	Intact forest loss 2002 - 2014 (km^2)	Drivers
Shan	6,326.06	Over 1,625 km^2 of intact forest have been converted to plantations, concentrated in the Middle Ayeyarwady HEZ.
Sagaing	2,798.61	Mining disturbance increased from approximately 70 km^2 to over 590 km^2, concentrated in central Sagaing Region in the Middle Ayeyarwady HEZ.
Kachin	2,090.47	Over 743 km^2 of forest converted to plantations in the central part of the state and over 180 km^2 of forest converted for mining in the Upper Ayeyarwady.
Chin	1,135.3	Conversion of intact forest to degraded forests was the largest cause of intact forest loss in the Chindwin HEZ.
Bago	1,041.68	539.36 km^2 of forest that have been converted to water bodies through the development of reservoirs in the Lower Ayeyarwady HEZ.
Magway	635.51	Over 108 km^2 of intact forest have been converted to plantations in the northern part of the state in the Middle Ayeyarwady.
Ayeyarwady	600.82	Over 46 km^2 of intact forest has been converted to plantations, mainly loss of mangroves in the Ayeyarwady Delta.
Mandalay	403.81	Fragmented areas of intact forest west of the city of Mandalay have been converted into non-forest in the Middle Ayeyarwady HEZ.
Yangon	100.62	About 30 km^2 of intact forest have been converted to plantation and over 26 km^2 were from development of new reservoirs in the Lower Ayeyarwady HEZ.

The High-Resolution Global Maps of 21st-Century Forest Cover Change (Hansen et al., 2013) was also used to estimate forest cover change in Myanmar from 2000 - 2015. Figure 59 highlights forest cover change in 2000 and 2015; further GIS analysis has been used to calculate total forest loss and gain in the Ayeyarwady Basin.

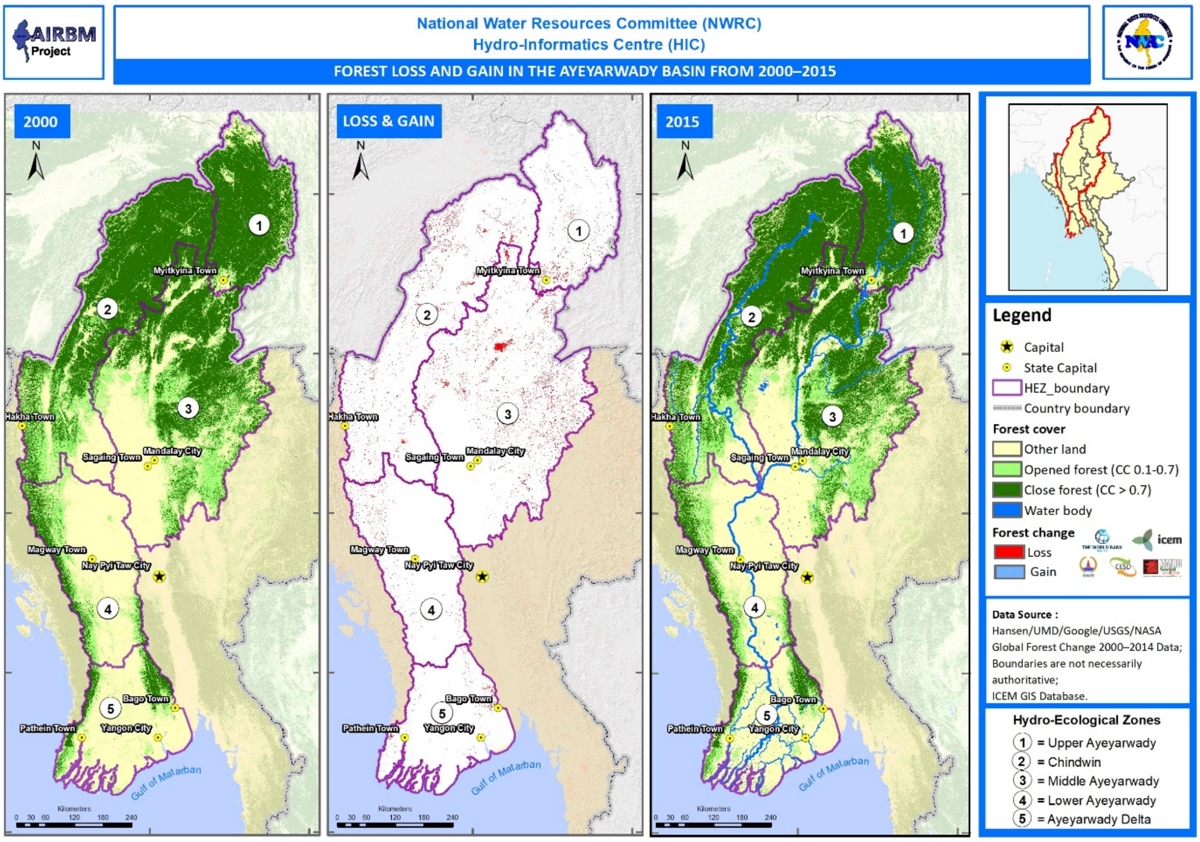


Figure 59 - Forest loss and gain in the Ayeyarwady Basin from 2000 - 2015

(Modified from Hansen et al., 2013)

The total forest loss calculated in the Ayeyarwady Basin from 2000 - 2015 is 8,914.6 km^2, with the highest total forest loss occurring in the Middle Ayeyarwady (3,385.9 km^2). This calculates to an overall decline of forest cover of 2.37% in the Ayeyarwady Basin.

Table 66 - Total forest loss in the hydro-ecological zones of the Ayeyarwady Basin from 2000 – 2015

(Modified from Hansen et al., 2013)

Ayeyarwady Basin HEZ	State/region	Area (km^2)	Forest cover	Forest loss	Total
Upper Ayeyarwady	Kachin	72,235	72,148.1	2,047.8	74,195.9
Chindwin	Chin	12,666	12,294.1	312.4	12,606.6
	Kachin	16,772	16,750.8	485.3	17,236.1
	Magway	5,352	5,202.1	100.7	5,302.8
	Sagaing	62,597	61,590.6	1,743.1	63,333.7
Middle Ayeyarwady	Magway	60	59.3	0.1	59.4
	Sagaing	31,115	30,304.6	920.3	31,224.8
	Shan	46,659	44,370.0	2,289.2	46,659.2
	Mandalay	24,641	24,275.4	176.4	24,451.8
Lower Ayeyarwady	Ayeyarwady	1,520	1,469.7	3.9	1,473.6
	Bago	9,115	8,802.3	61.1	8,863.4
	Chin	3,925	3,733.2	128.9	3,862.1

Ayeyarwady Basin HEZ	State/region	Area (km²)	Forest cover	Forest loss	Total
	Magway	39,523	38,363.9	395.3	38,759.2
	Sagaing	148	141.3	5.3	146.6
	Mandalay	5,129	5,057.3	0.2	5,057.5
Delta	Ayeyarwady	31,197	29,851.2	153.7	30,004.9
	Bago	5,133	4,935.1	39.9	4,974.9
	Yangon	6,903	6,608.2	51.0	6,659.3
TOTAL		**374,690**	**365,957.3**	**8,914.6**	**374,871.8**

There was an increase of 1,568.1 km² of forest cover from 2000 - 2015, with the most forest regenerated in the Middle Ayeyarwady (728.1 km²).

Table 67 - Total forest gain in the hydro-ecological zones of the Ayeyarwady Basin from 2000 – 2015

(Modified from Hansen et al., 2013)

Ayeyarwady Basin HEZ	State/region	Area (km²)	Forest cover	Forest gain	Total
Upper Ayeyarwady	Kachin	72,235	73,792.3	248.2	74,195.9
Chindwin	Chin	12,666	12,532.1	403.6	12,606.6
	Kachin	16,772	17,178.6	74.4	17,236.1
	Magway	5,352	5,297.0	57.5	5,302.8
	Sagaing	62,597	63,012.7	5.8	63,333.7
Middle Ayeyarwady	Magway	60	59.4	321.1	59.4
	Sagaing	31,115	31,185.4	-	31,224.8
	Shan	46,659	46,307.9	39.4	46,659.2
	Mandalay	24,641	24,435.5	351.3	24,451.8
Lower Ayeyarwady	Ayeyarwady	1,520	1,473.2	16.3	1,473.6
	Bago	9,115	8,859.6	0.5	8,863.4
	Chin	3,925	3,836.6	3.8	3,862.1
	Magway	39,523	38,733.3	25.5	38,759.2
	Sagaing	148	146.6	25.9	146.6
	Mandalay	5,129	5,057.5	0.0	5,057.5
Delta	Ayeyarwady	31,197	29,996.0	0.0	30,004.9
	Bago	5,133	4,971.1	8.8	4,974.9
	Yangon	6,903	6,657.8	3.8	6,659.3
Total		**374,690**	**373,532.6**	**1,586.1**	**374,871.8**

6.2.2 *Identifying local hotspots for intact forest loss*

These studies may produce different results for forest loss and may overestimate the level of forest cover overall, however they do present a means of identifying forest and land cover changes that can identify hotspots to inform more sustainable forest management. The data has been used to identify hotspots for remaining intact forest (Figure 60) and intact forest loss from 2002 - 2014 (Figure 61) by township in the Ayeyarwady Basin.

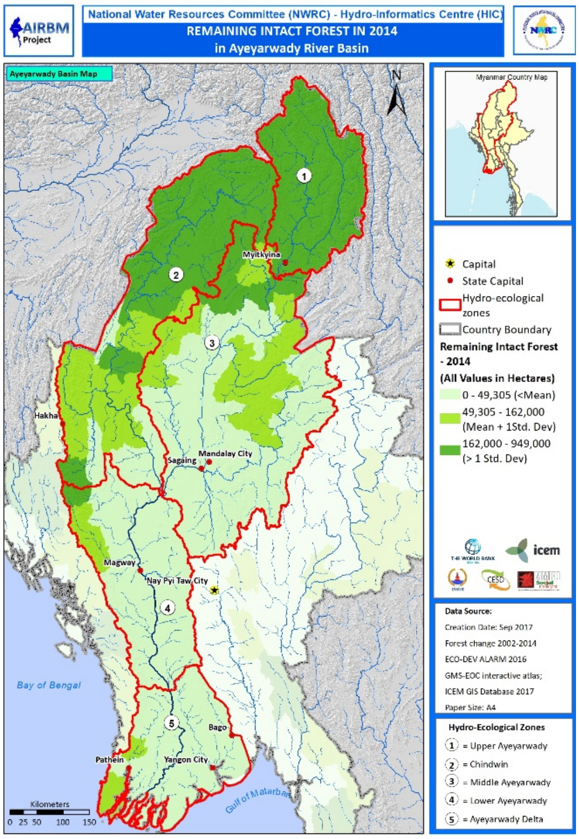


Figure 60 - Areas showing the extent of remaining intact forest in the Ayeyarwady Basin

(Bhagwat et al., 2017)

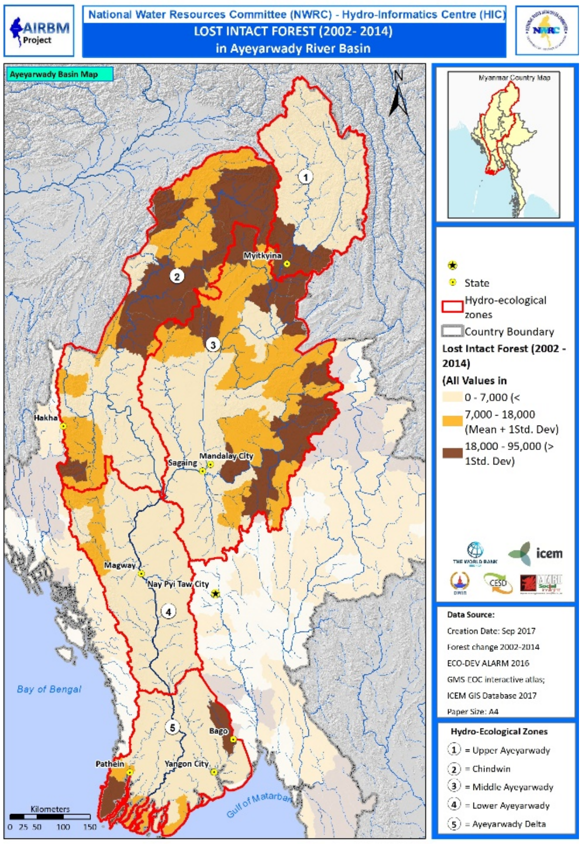


Figure 61 - Areas of forest loss in the Ayeyarwady Basin

(Bhagwat et al., 2017)

Local hotspots highlighted in the Ayeyarwady Basin were Homalin Township in the Sagaing Region and Hpakant Township in Kachin State; these areas are shown below in Figure 62 and Figure 63 respectively. Mining is concentrated to the south and west of the city of Homalin and Hpakant is a centre for jade mining. Other hotspots identified in the Ayeyarwady Basin were clearings for plantations around Myitkyina, along the Ayeyarwady River and around Tanai in the Kachin State (Bhagwat et al., 2017).

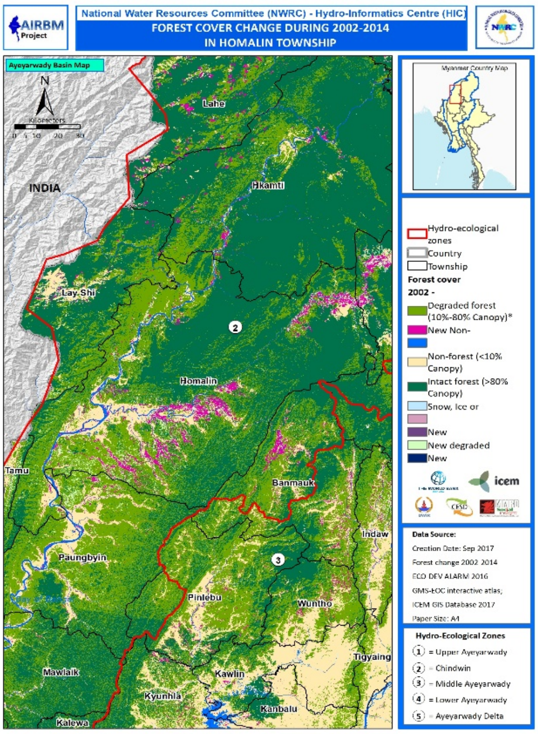


Figure 62 - Forest cover change from 2002 - 2014 in the Homalin Township, Sagaing Region

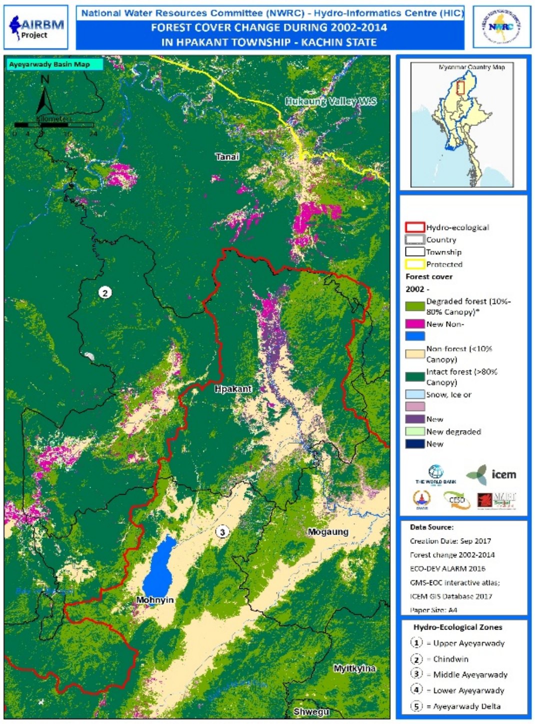


Figure 63 - Forest cover change from 2002 - 2014 in the Hpakant Township, Kachin State

6.2.3 *Loss of mangroves*

The loss of mangrove forests in the Ayeyarwady Delta Region was also identified as a hotspot for deforestation. Myanmar has the third largest area of mangroves in Southeast Asia (NBSAP, 2015), with coastal mangrove forests providing valuable habitats for marine biodiversity, acting as a carbon storage, and helping to protect communities from flooding and storm surges.

In 2013, the Ayeyarwady Delta saw the largest loss of mangrove forests at 356 km^2, followed by Rakhine at 264 km^2 and Tanintharyi at 35 km^2. The delta originally held a much larger proportion of mangroves, however deforestation rates prior to 2000 coupled with high population density resulted in this region containing the lowest mangrove area of the three. The mangrove cover in the Ayeyarwady Delta has decreased from 2,747.89 km^2 in 1980 to 450.48 km^2 in 2013. Mangrove forest cover in 1978, 1989, 2000, and 2011 is shown below in Figure 64.

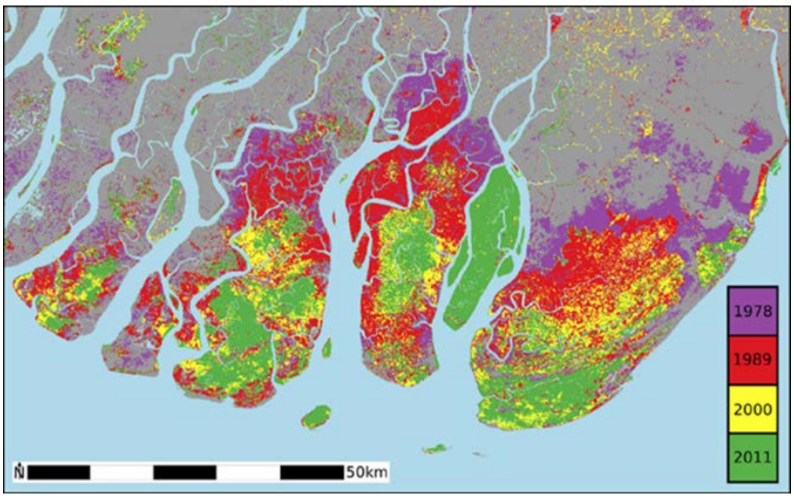


Figure 64 - Changes in mangrove forest cover 1978/1989/2000/2011

(Weber et al. 2014)

The most significant driver of mangrove loss in Myanmar is rice production, which accounts for 87.6% of mangrove deforestation between 2000 and 2012 (Richards and Friess, 2016). Of particular concern is the Ayeyarwady Delta, an expansive alluvial floodplain originally home to the largest tract of mangroves in Myanmar, but which has sustained high rates of deforestation. Cyclone Nargis also had a severe impact on mangrove cover in 2008 and currently aquaculture is reported to have much less impact. A recent spatial assessment found that only 1.6% of mangrove deforestation between 2000 and 2012 could be attributed to aquaculture in Myanmar (Richards and Friess, 2016).

6.2.4 Drivers of forest loss

The main drivers of forest loss in Myanmar and the Ayeyarwady Basin are:

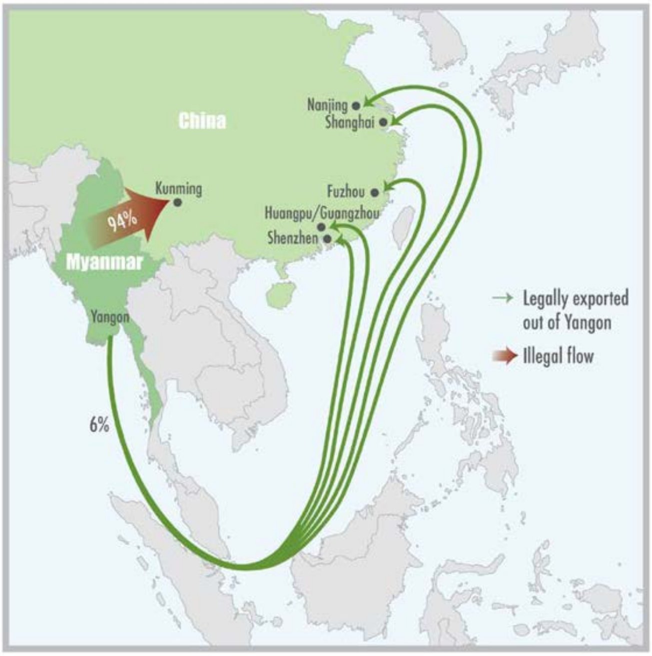
- illegal logging;
- unsustainable harvesting of timber;
- land concessions for agribusiness;
- swidden agriculture;
- production of fuelwood and charcoal; and
- timber extracted from the clearing of land for roads and other infrastructure, i.e., HP, mining, and SEZs.

The drivers of deforestation and forest degradation are summarized in the following sections.

a) Illegal logging

Myanmar's illegal wood trade includes timber, fuelwood, and charcoal. Demand from the wood processing industries and plantation sectors in China, Vietnam, and Thailand exerts pressure on Myanmar's forests. These demands are intensified by logging controls in these countries' own forests and Myanmar's stock of valuable species, notably its prized teak (*Tectona grandis*) and rosewoods/redwoods (*Dalbergia spp.*; Kissinger, 2017). Estimates indicate that between 2001 and 2013, 10.2 million cubic metres (M m^3) of Myanmar logs imported into global markets were not authorized for harvest, which would equate for a 47.7% illegal logging rate in the country related to exports (EIA, 2014). Global Witness calculated that at least 1.0 M m^3 of timber was exported illegally from Myanmar across the China border in 2002 alone (Global Witness, 2003).

The governments of Myanmar and China banned overland trade of timber products in 2006. The Government of Myanmar requires that all timber products be stamped by the MTE and exported by sea from the southern port. However, in 2013, it was estimated that 94% of Myanmar's timber product exports to China were registered in Kunming in Yunnan province which borders Kachin State in Myanmar (Forest Trends, 2015; Figure 65). In 2011, 80% of the teak and hardwood ocean shipments from Myanmar went to India, which had emerged as a lucrative market for timber exports.



*Does not include timber sent through other countries before being re-exported to mainland China. In 2013, 94% of China's imports of Myanmar timber were registered in Kunming.

Figure 65 - Illegal flow of timber products

(Forest Trends. 2015)

Overall export volumes declined for several years following the ban on overland trade. However, apart from a dip in 2012, which was likely due to the onset of war again in Kachin State, volumes have been rising steadily since 2009. They reached a record 1.7 M m^3 in 2013 (Woods, 2015). The increase in log exports in 2013 may have been driven in part by traders taking advantage of a window of reduced violence between the Kachin Independence Army (KIA) and the Tatmadaw (Myanmar Army) and in advance of the monsoon season (Forest Trends, 2014). Experts also speculate that there was a rush to transport increased volumes of teak and hardwood in anticipation of Myanmar's log export ban, which was enacted on April 1, 2014. Data indicated that in 2014, 92% of rosewood log imports were registered in Kunming with US$ 52 million worth of rosewood logs transported across the border in the month after the ban was enacted (Treanor, 2015).

The log export ban in 2014 had a significant impact on the forestry sector and the local timber market in Myanmar. The value of timber products exported from Myanmar to China rose steadily through 2000 - 2012, and increased significantly from US$ 620 million in 2013 from US$ 309 million in 2012. The log export ban also had a distinct impact on international markets. China had previously imported 80% of its teak from Myanmar. The log export ban triggered a rapid increase in demand for teak, with a steep rise in prices from approximately US$ 750 per m^3 at the end of 2013 to almost US$ 2,000 per m^3 in January 2014 (FAO, 2015a).

Immediately before the ban entered force, the district FDs observed a considerable rise in prohibited harvests, log smuggling, and illegal exports. Exports peaked at more than 40,000 m^3 in March 2014, the month before the ban came into force. After the ban was enacted, logs could no longer be legally exported and had to be processed locally. The tenders conducted by the MTE were not frequented by international buyers and, as a result, teak prices reportedly fell by up to 40% (Kissinger, 2017).

China's demand for rosewood (*Dalbergia spp.)* and padauk (*Pterocarpus macrocarpus*) has also acted as a large driver of Myanmar's illegal logging. Rosewood is a particularly lucrative type of timber used to make furniture and rosewood tree species are highly threatened by targeted logging (Treanor, 2015). Overland transport of illegally harvested rosewood also increased in the first quarter of 2014 prior to the logging ban. The October 2016 listing of Dalbergia in Annex II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora offers an opportunity to protect these forests from logging.

Myanmar is also one of the world's largest exporters of fuelwood and charcoal (2.8% of the global share). All fuelwood and charcoal is transported overland, which indicates that the export is also illegal under Myanmar's laws (Kissinger, 2017).

b) Unsustainable harvesting of timber

Unsustainable levels of timber extraction for commercial use, especially for high value teak and other hardwoods, has been another driver of deforestation. Several reports have indicated that exploiting the forest above the Annual Allowable Cut (AAC), disregarding the Myanmar Selection System and granting permission to cut trees of immature size have been just has harmful as illegal logging practices (Kissinger, 2017).

Official logging levels are reported to have regularly exceeded the sustainable level of timber harvestings (Springate-Baginski et al., 2016). Figure 66 and Figure 67compare the ACC to actual levels of extraction, including conservative estimates of wastage and illegal extraction. These patterns continued in the year leading up to the ban on exports. In the Ayeyarwady Basin, official teak extraction in the Sagaing Region alone exceeded the national AAC in 2013 - 2014.

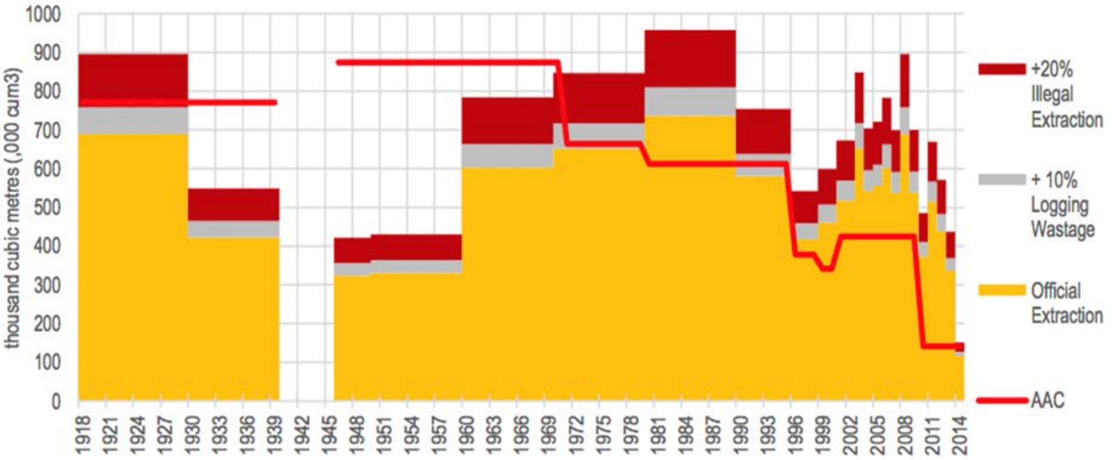


Figure 66 - Teak AAC and production plus estimated wastage and illegal extraction

(Springate-Baginski et al., 2016)

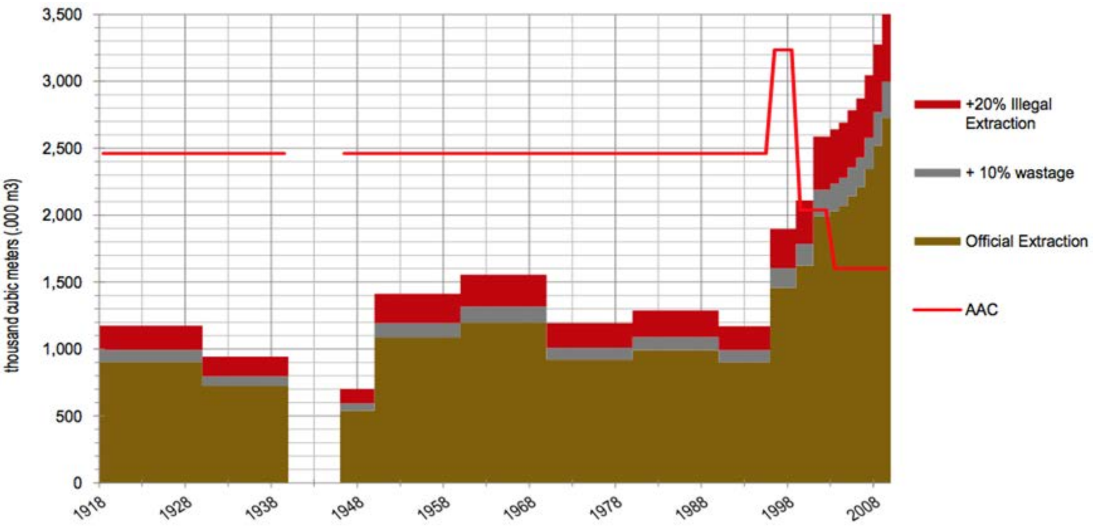


Figure 67 - Other hardwood AAC and production plus estimated wastage and illegal extraction

(Springate-Baginski et al., 2016)

There is general consensus that there were high rates of change in closed forests during the mid-2000s, which decreased after 2006 - 2007, though harvesting of teak and hardwoods were still above the established AAC (Kissinger, 2017). Other reasons for overharvesting include conversion of forest to agricultural use, supplying the illegal timber trade, lack of land tenure, conflict in ethnic regions, and lack of environmental and social impact assessments.

Springate-Baginsky et al. (2016) highlight that forests have been systematically over-logged for decades; past military governments focused heavily on log exports and significantly exceeded AAC. Overharvesting is an issue in the Ayeyarwady Basin. Treue et al. (2016) observed in Sagaing region and Kachin state that harvested logs in natural teak forests were only just above the minimum girth of 6'6" at breast height (1.3 m above ground level); compartments that were cleared for teak 7 - 10 years ago have not been allowed to recover for the prescribed 30 years, but had recently been re-entered for the extraction of other hardwoods. The records from Katha, one of the main Forest Management Units in Sagaing Region, revealed that in every year felling has exceeded the AAC level, and in 2013 - 2014 just prior to the export logging ban felling exceeded the ACC by almost 500% (EIA, 2014).

Some reports note that the commercial legal logging carried out by MTE fluctuates around, but does not consistently violate, the ACC that was fixed under the Myanmar Selection System. For instance, AAC fixed for periods before and after 1996 were 1.3 and 1.8 Mt respectively and actual felling has never exceeded the AAC limits (Tint et al., 2011). Therefore these studies conclude that illegal logging has had more of an impact on forest loss than overharvesting.

The new NLD government introduced a temporary logging ban as part of the 100-day plan; the ban prohibited timber harvesting in the 2016 - 2017 season. Beginning in the fiscal year of 2017 - 2018, the AAC was set to 19,2010 teak trees and 593,330 other hardwood trees. The MTE plans to harvest only 15,280 t of teak and 300,000 t of hardwood, both of which fall below the AAC (Myanmar Timber Enterprise, 2016).

Prior to this, the FD and MTE had taken steps to reduce the ACC. The FD sets AAC and defines teak and hardwood felling marking. The MTE is then responsible for harvesting, milling and downstream processing, and marketing of forest products. Since 2014 - 2015, the MTE has reduced the harvesting amount to within the limit of AAC prescriptions set by FD. Plans to establish the voluntary partnership agreement (VPA) with the EU under the FLEGT Action Plan is an important step in timber certification in Myanmar. Myanmar's progress on teak and hardwood certification is presented separately in Chapter 12 - Case Studies.

c) Concessions for agribusiness

One of the largest drivers shifting forest to non-forest uses has been clearing forest for potential use for agriculture. Clearings for agriculture have occurred in and outside of the PFE and 'Unclassified' forests, which typically have less tree cover and are most vulnerable to shifting to agribusiness concessions (Kissinger, 2017).

The agribusiness concessions allocated within forests between 2010 and 2013 largely resulted in forest conversion and timber production. Evidence suggests that these concessions were used for the extraction of timber rather than to develop plantations as by the end of the period only approximately 25% of the land allocated for agribusiness concessions had been planted (Woods, 2015). Table 68 shows the agribusiness concessions allocated (ha) and planted (ha) in the states/regions of the Ayeyarwady Basin. This does not include concessions granted by sub-national government or EAGs. This pattern is illustrated for the states/regions of the Ayeyarwady Basin in Figure 68.

Table 68 - Agribusiness concessions in Ayeyarwady Basin states/regions

(Woods, 2015)

State/region	Allocated (km²)				Planted (km²)	
	2010/2011	2011/2012	2012/2013	% of concessions	By July 2013	% planted
Kachin	2,412.66	5,651.74	7,676.77	52.0	1,455.38	18.9
Sagaing	404.92	1,049.24	2,158.62	14.6	697.81	32.3
Ayeyarwady	782.47	1,156.77	1,357.04	9.2	862.28	63.5
Shan	473.87	650.03	1,310.51	8.9	487.49	37.2
Magway	819.46	855.07	888.6	6.0	388.48	43.7
Bago	80.01	211.8	809.98	5.5	368.75	45.5
Yangon	125.36	125.37	324.59	2.2	308.7	95.1
Mandalay	41.68	25.34	226.81	1.5	58.7	25.9
Chin	0	6.24	7.05	0.0	.48	6.8
Total	**514,043**	**973,161**	**1,475,997**		**462,807**	**31.3**

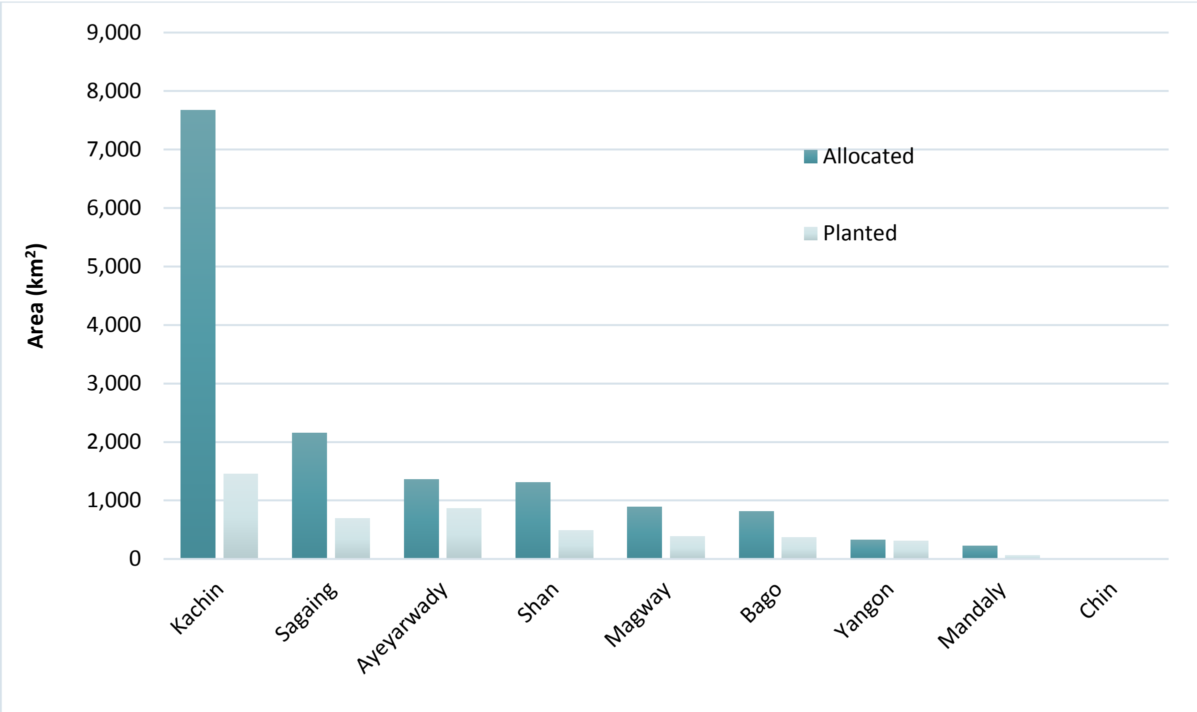


Figure 68 - Agribusiness concessions in Ayeyarwady Basin states/regions

(Woods, 2015)

In the states/regions of the Ayeyarwady Basin, 462,807 ha of agribusiness concessions had been allocated as of July 2013 and 31.3% had been planted. Most of the agribusiness concessions were granted in Kachin State (767,677 ha) and only 18.9% had been planted, whereas in Sagaing Region 215,862 ha had been allocated while 32.3% had been planted. Between 2002 and 2014, new large-scale plantations for agricultural products (e.g., cassava, rubber, and betel nut) occurred in Kachin state and Sagaing region (Treue et al., 2016). Kachin state's plantation area, which predominantly grows rubber, increased primarily as extensions of existing plantations along rivers and on the edge of degraded and intact forest areas. Sagaing region had a modest expansion of an already large agricultural area, while plantations also expanded.

One of the new areas opening up for agribusiness projects are the cassava plantations in the Hukaung Valley in western Kachin State. Figure 69 below shows the change in forest cover from 2002 - 2014 in the Hukaung valley, highlighting changes from intact forest to new plantation and new non-forest (Bhagwat et al., 2017). Clearance of forest has occurred within and around the boundaries of the Hukaung Wildlife Sanctuary.

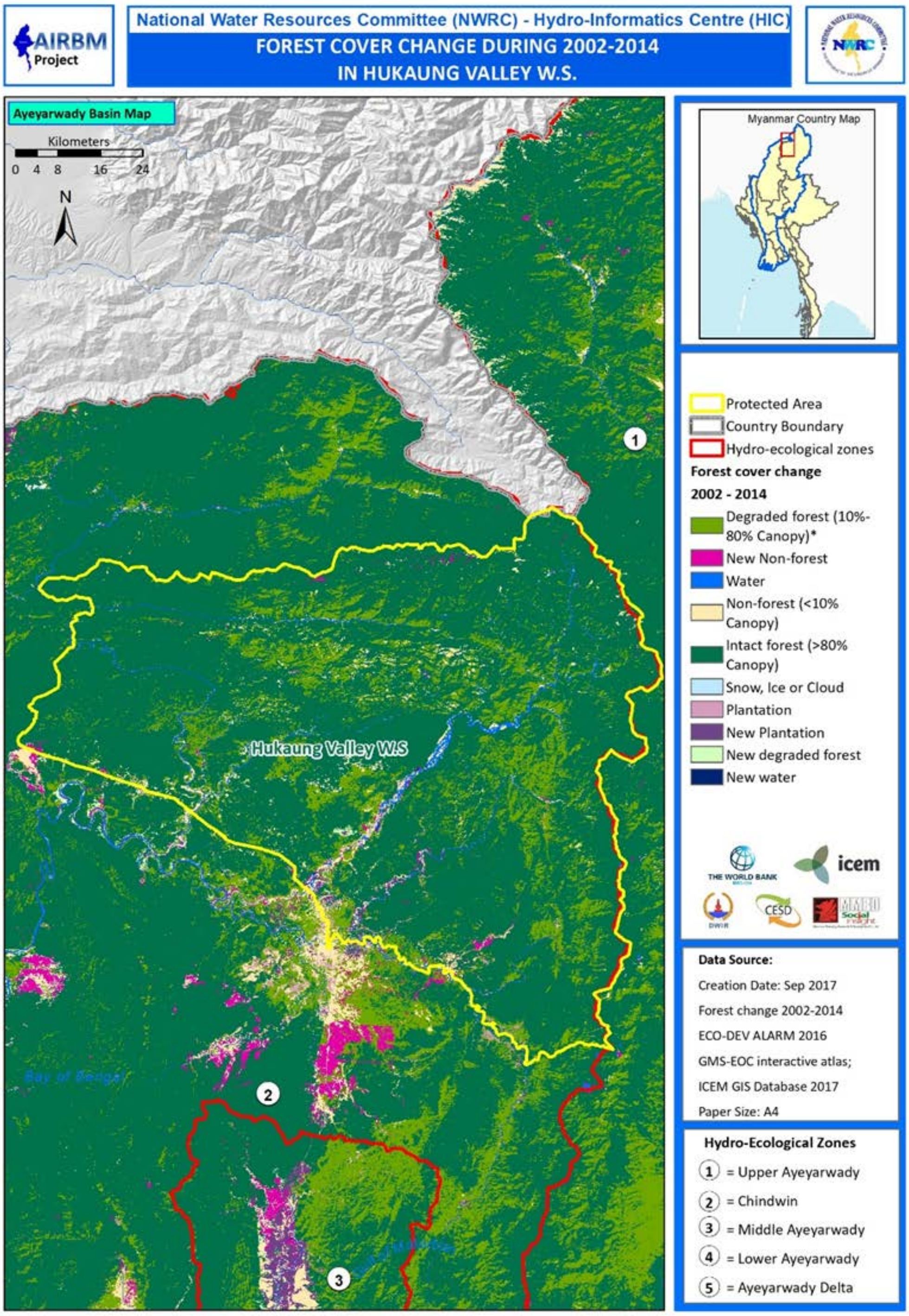


Figure 69 - Forest Cover Change 2012 - 2014 in Hukaung Valley

The Myanmar National Export Strategy prioritizes rubber as an export crop, though exports have not been stronger in recent years due to low rubber prices. Most increases in rubber production are through the expansion of planted area rather than increases in yields on plantations. Along the Chinese border in Kachin and Shan States, rubber production has been pushed as a perennial crop substitution for the opium poppy.

It is estimated that rubber plantation areas in Kachin and Shan states cover an area of approximately 700 km^2.

Between 2005 and 2015, the area under agriculture has increased by approximately 10,000 km^2, though there is no consensus on which land use categories the expansion came from (Kissinger, 2017). The scale of concessions for major agribusiness interests is estimated to be roughly 13.5 million ha, and low utilization of these concessions makes projecting future use of these land unpredictable.

The Master Plan for the Agriculture Sector (2000 - 2001 to 2030 - 2031) developed by MOALI aims to convert 40,500 km^2 of 'wasteland' to private industrial agricultural production, and to promote the expansion of rubber, oil palm, paddy, pulses, and sugarcane. Much of this land contains residents under customary use and unclarified tenure and also contains forests and significant biodiversity. These areas are under the management of MOALI through the VFV lands Management Law and although the Forest Law allows for the management of forest outside the PFE, it is not clear how management will be implemented within these overlapping mandates. Further discussion on the VFV Law and Farmland Law are provided in Section 5 - Agriculture.

Other contributing factors to deforestation may include the conversion of land for small scale - generally household - agricultural production, and the extension and/or intensification of swidden agriculture. However, these factors seem to be of secondary consideration for the forestry sector because they generally take place in areas where forest resources are already degraded and of limited commercial value.

About 42% of the country's population lives in upland areas and are likely to be practicing some form of shifting cultivation, which affects between 20,000 and 40,000 km^2 of mostly unclassified forested areas (Kissinger, 2017). The impacts of shifting cultivation on forest loss and forest degradation must be evaluated carefully as the practice is an important livelihood activity in the mountainous areas of the Ayeyarwady Basin. There seems to be little available data on the extent of this type of land conversion. Indeed, a recent report on the drivers of deforestation and forest degradation in Myanmar found that there was insufficient information to determine whether or not swidden cultivation was a contributing factor to deforestation in Myanmar.

a) Mining

Roughly 4,600 km^2 is believed to have been cleared for mining since 2002; an additional 3,700 km^2 of cleared land is highly likely to have been cleared for mining. Kachin state and Sagaing region have the largest areas of land cleared for mining. Further analysis of mining disturbance and concessions is provided in Section 7 - Mining.

b) Hydropower

Forest loss has occurred as a result of HP development and more than 200 irrigation reservoirs located in the Ayeyarwady Basin. There are 17 existing and under construction projects in the Ayeyarwady Basin with an installed capacity of 3,472 MW, it is estimated that these projects inundate approximately 846 km^2. In addition, there are 32 planned projects with an installed capacity of 28,077 MW could potentially inundate a further 1,406 km^2 of forest and arable land (IFC et al., 2017). During construction the influx of a large numbers of construction workers who are employed for civil work and live on site for the duration of the project can lead to increased demand for forest resources and exploitation of wildlife. Hydropower development may lead to displacement and resettlement of people and communities who are moved to the uplands may practice swidden agriculture. The impacts and benefits of HP development are further described in Section 8 - Energy.

c) Roads and other infrastructure

The development of roads and other infrastructure such as power lines, oil and gas pipelines, railroads, and canals is known to have significant impacts on forests. Currently a range of infrastructure developments are taking place in forested areas in the Ayeyarwady Basin, including the development of transport infrastructure, power generation infrastructure (HP plants in particular), and power T&D infrastructure. The development of roads and other infrastructure can lead to deforestation in the following ways:

1. Conversion of other land use types leads to the clearance or degradation of forests;
2. Better road access enables the extraction of timber, fuelwood, and other NTFPs (illegally or otherwise);
3. The construction of roads for logging and transportation also has adverse impacts on forest ecosystem health, and facilitates subsequent illicit logging in the selectively logged areas.

The future impacts on forests from the development of roads, hydropower projects (HPPs), pipelines, SEZs, and power lines requires further assessment in relation to sustainable forest management and river basin planning.

6.3 Timber Production

Forestry represents a relatively small and declining share of GDP due to very high growth in the industrial and service sectors, and in part due to declining productivity in remaining forests (see Figure 70). Timber production in the sector has declined in part due to policies banning the export of raw timber. Teak reportedly accounted for 70 - 80% of this value, although in recent years a boom in demand for rosewood in China has led to a significant increase in the importance of this trade. Illegally exported timber is not accounted for in official statistics and is typically smuggled across the border to China by road.

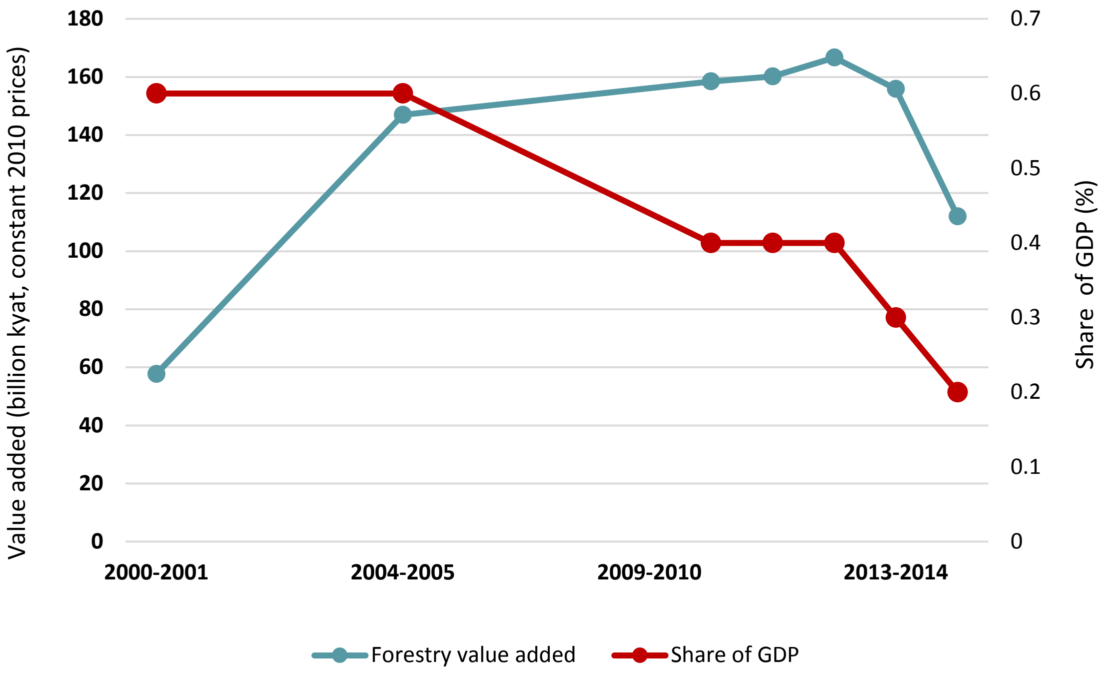


Figure 70 - Forestry value added and share of national GDP 2001/2002 - 2013/2014

(IFC et al., 2017)

Timber and wood products still maintain a sizable share in export revenues and remain an important source of foreign exchange earnings. Figure 71 shows the rapid increase in the value of timber exports to over US$ 1.6 billion in 2013, which more than tripled since the early 2000s. These figures are derived from customs statistics from importing countries as these are deemed to be a better guide than Myanmar's own production and export statistics which miss large portions of illegally exported wood (FAO, 2015b).

Teak reportedly accounted for 70 - 80% of this value, although in recent years a boom in demand for rosewood in China has led to a significant increase in the importance of this trade (Treanor, 2015). Reported export volumes, which peaked in 2005, were approaching peak levels again in 2013. Recent years have also seen an increase in the share of raw timber in exports, as export priorities have overridden considerations of the development of domestic productivity (Woods and Carnaby, 2011). This trend has been reversed somewhat with the implementation of the 2014 timber export ban.

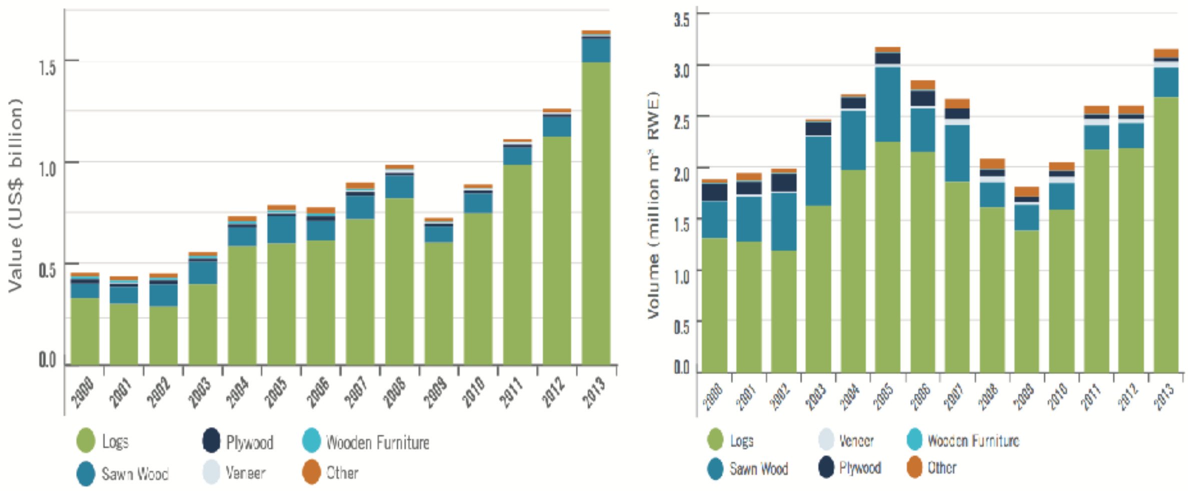


Figure 71 - Timber exports by value (a) and volume (M m³) Round Wood Equivalent (b) 2000 - 2013

(Woods, 2015)

There is strong market demand for Myanmar's timber, and a significant portion of that market does not currently screen for legality. With the difficulty of enforcing the 2014 raw log export ban, future trends for the next few years will likely track those of the last five years, as long as supply can be met.

There is also strong demand for charcoal and fuelwood. Estimates of overall fuelwood use are uncertain, however there seems to be consensus in the literature that for approximately the last decade fuelwood consumption has been approximately 20 Mt (IFC et al., 2017). It is unclear if these figures include charcoal production for domestic use, which is estimated to be between 94,000 t and 207,000 t per anum. The figures do not seem to account for the growing charcoal export trade to China, which has grown from virtually nothing before 2007 to represent approximately 32% of China's timber imports from Myanmar by volume by 2013 (500,000 m³; Forest Trends, 2014).

In addition to fuelwood and charcoal, a broad range of NTFPs are harvested at a commercial scale from forests, including bamboo, rattan, barks, resins and oils, honey, beeswax, bat guano, orchids, edible birds' nets, and lac. A wide range of wildlife species are also harvested from the forests, much of it taken illegally (IFC et al., 2017). Most of these products are used to support subsistence livelihoods, along with wild foods and natural medicines. A recent valuation study suggested that the economic value of NTFPs in 2012 was approximately US$ 487 million in terrestrial forests and US$ 20 million in mangrove forests (Emerton and Aung, 2013).

Major discrepancies in the trade data surrounding Myanmar's timber product make it difficult to analyze the situation in-depth. When looking at the trade statistics of Myanmar's exports, it is important to note that there are significant differences in data between international sources and national statistics.

6.3.1 Teak and hardwood extraction

The global area of natural teak forests is estimated at approximately 290,000 km², almost half of which is located in Myanmar. Natural teak forests are a particularly precious resource that produces high quality logs that sell at comparatively high prices. Myanmar is also the primary producer of teak logs; in 2010, its natural forests produced a quarter of the globally reported teak log removals. Myanmar has the third largest planted teak area in the world - approximately 3,900 km² of an estimated total area of 43,500 km² (Kollert and Cherubini, 2012). The teak and hardwood extracted from the state/regions of the Ayeyarwady Basin is shown below in Figure 72. The log export ban has been successful in reducing the volume of teak and hardwood extracted from forests and plantations in the Ayeyarwady Basin from approximately 1,176,222 m³ in 2012 - 2013 to 546,428 m³ in 2015 - 2016. However, these figures do not capture illegal logging.

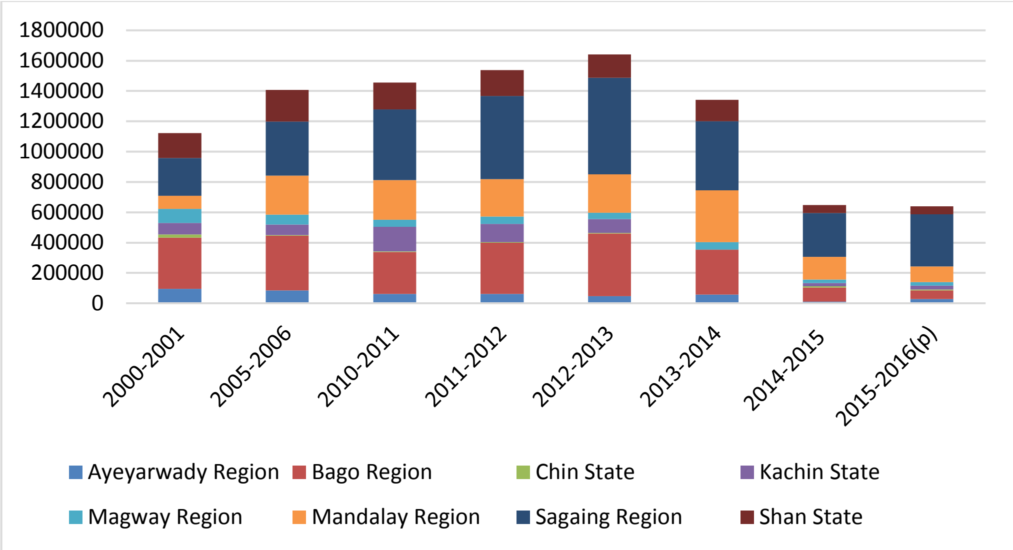


Figure 72 - Teak and hardwood extraction (m3) by state/region in the Ayeyarwady Basin

(Myanmar Statistical Yearbook 2016, Myanmar Timber Enterprise)

In 2015 - 2016, approximately 692,066 m^3 of teak and hardwood were extracted in Myanmar. Most of this, or 84% (546,428 m^3), was extracted from states/regions of the Ayeyarwady Basin, mostly from Kachin state, Sagaing region, and Mandalay region. Figure 73 below compares teak and hardwood extraction from the Ayeyarwady Basin from 2000 - 2001 to 2014 - 2015. Generally, timber extraction has declined in the Ayeyarwady Basin, with Bago Region declining from 139,717.0 m^3 in 2000 - 2001 to 38,455.6 m^3 in 2014 - 2015 and Magway Region declining from 38,465.1 m^3 to 9,818.7 m^3 in the same period. Mandalay Region increased extraction from 35,761.8 m^3 in 2000 - 2001 to 62,352.2 m^3 in 2014 - 2015. Plans for teak and hardwood certification are an important move towards more sustainable forest management and are discussed in-depth in Chapter 12 - Case Studies.

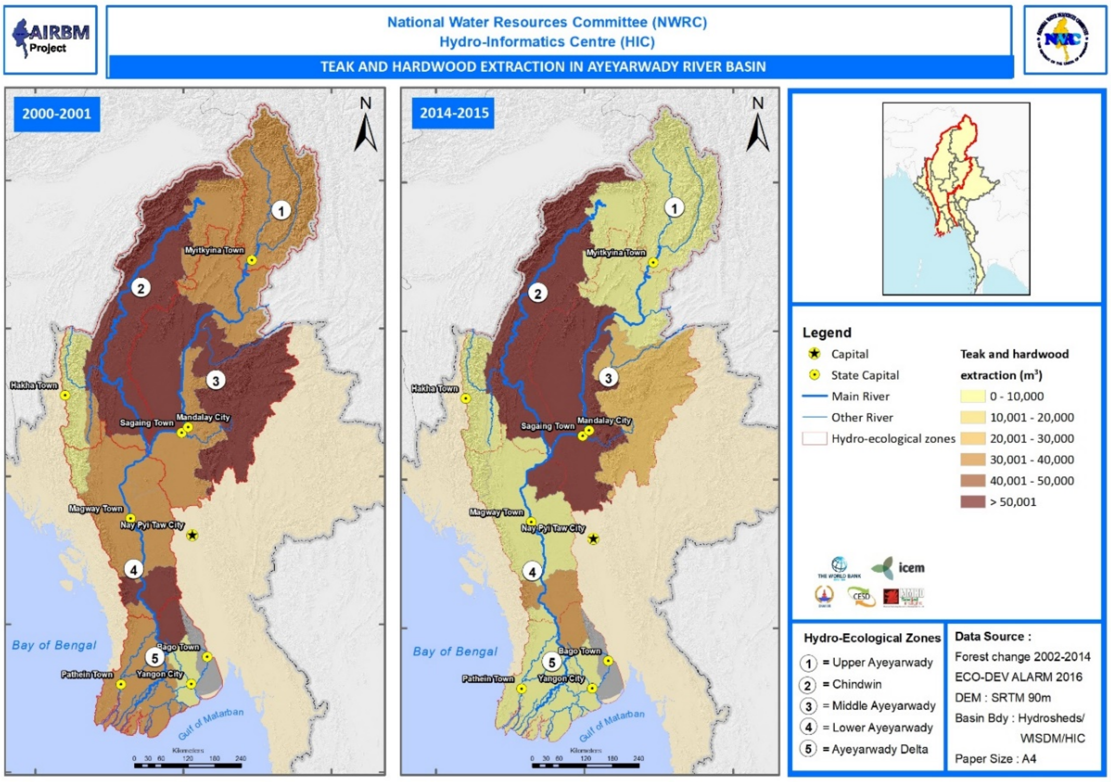


Figure 73 - Teak and hardwood extraction in 2000 - 01 and 2014 - 15

Key sources of timber production over the last decade in the Ayeyarwady Basin have been Mandalay region, Sagaing region, Shan state, and Bago region for teak, and Sagaing region, Mandalay region, and Bago region for other hardwoods. It is important to note that these do not take account of illegally extracted timber or wastage (Springate-Baginski, 2015). The recent export ban is reflected in the decline in production in 2014 - 2015, however in terms of illegal logging, Sagaing region and Kachin state remain an important source of timber for the Chinese market (Kissinger, 2017).

6.3.2 *Teak and hardwood plantations*

The Myanmar Forest Policy 1995 encourages forest plantation establishment in order to supply local and industrial use and to increase reforestation of degraded lands. Four categories of plantations exist (Table 69):

1. Commercial (for marketable wood, both domestic and for export);
2. Local supply (village woodlots for firewood, posts, and poles);
3. Industrial (for supplying raw material to pulp and paper factories); and
4. Watershed (for water utilization, water catchments of dams, and irrigation flow).

Table 69 - Type and area (km^2) of forest plantations in Myanmar

(FD, 2015)

Plantation Type	Description	Area (km^2)	% of total plantation area
Commercial	Marketable wood, both domestic and for export	4,905.65	55.6
Village supply	Village woodlots for firewood, posts and poles	725.19	8.2
Industrial	Supplying raw material to paper and pulp factories	136.849	15.5
Watershed	Water utilization, water catchments of dams and irrigation flow	1,820.19	20.6
	Total	**8,819.52**	**100**

The supply of quality teak logs originating from old-growth natural teak forests in Myanmar declined as a result of the log export ban. The increased interest and investment in establishing teak plantation was a result of declining harvestable area in natural teak forests and deteriorating quality of naturally grown teak (FAO, 2015). To maintain sustainable yield of timber and forest products, natural forest regeneration and artificial forest plantation have been carried out in Myanmar. Table 70 and Figure 74 show the area of teak plantation and number of trees planted from 2008 - 2009 to 2015 - 2016. From official government figures, the area of teak plantation increased by 497.23 km^2 from 3,341.78 km^2 in 2008 - 2009 to 3,839 km^2 in 2015 - 2016, with 5.532 million new teak trees planted.

Table 70 - Plantation of teak trees from 2008 - 2009 to 2015 - 2016

(FD, 2016)

Year	Area and number of trees at the beginning of the year		Area and number of trees planted during the year		Area and number of trees planted at the end of the year	
	Trees (in thousands)	km^2	Trees (in thousands)	km^2	Trees (in thousands)	km^2
2008 - 2009	35,710	3,211.45	1,469	132	37,180	3,341.78
2009 - 2010	37,180	3,343.58	1,548	139.13	38,728	3,480.92
2010 - 2011	38,728	3,482.79	1,390	124.92	40,118	3,605.84
2011 - 2012	40,118	3,607.78	1,105	99.29	41,223	3,705.14
2012 - 2013	41,223	3,707.13	554	49.75	41,777	3,754.89
2013 - 2014	41,777	3,756.9	536	48.13	42,311	3,803

Year	Area and number of trees at the beginning of the year		Area and number of trees planted during the year		Area and number of trees planted at the end of the year	
	Trees (in thousands)	km²	Trees (in thousands)	km²	Trees (in thousands)	km²
2014 - 2015	42,311	3,805	277	24.87	42,588	3,827.9
2015 - 2016 (p)	42,588	3,829.95	124	11.12	42,712	3,839

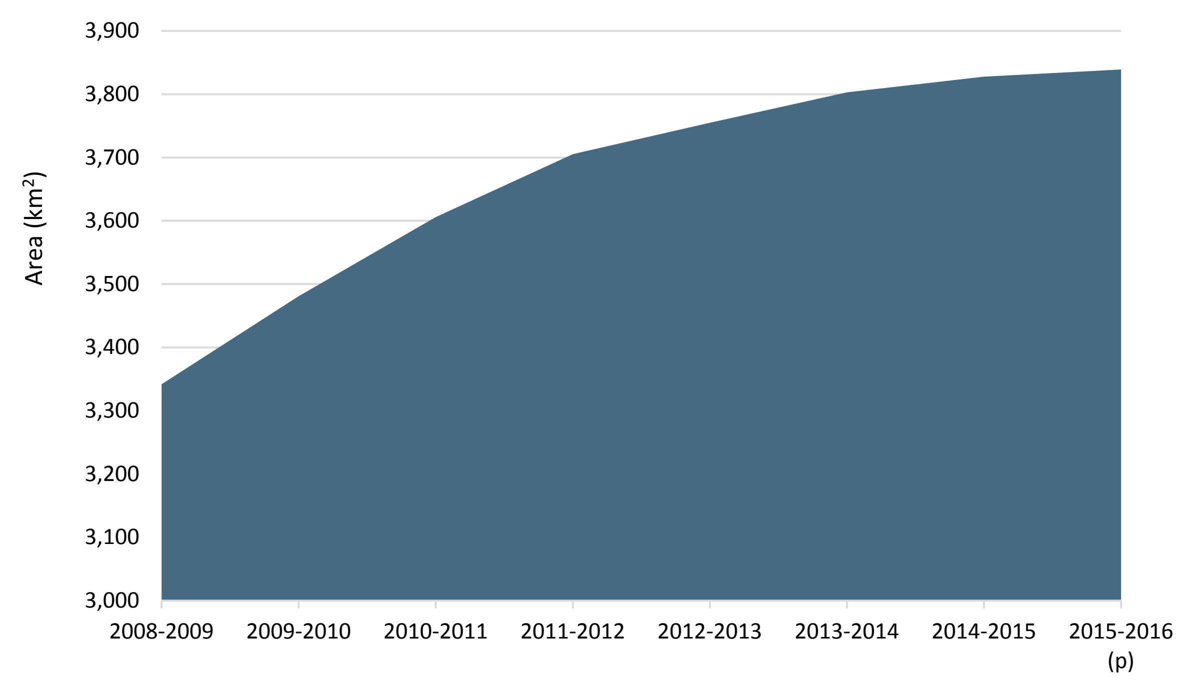


Figure 74 - Area (ha) of teak plantation from 2008 - 2009 to 2015 - 2016

Figure 75 and Table 71 show the area and number of hardwood trees planted from 2008 - 2009 to 2015 - 2016. From official government figures, the area of hardwood plantation increased by 156.87 km² from 4,813.29 km² to 4,971.97 km² in 2015 - 2016, with 1.765 million hardwood trees planted.

Table 71 - Plantation of hardwood from 2008 - 2009 to 2015 - 2016

Year	Area and number of trees planted during the year		Area and number of trees planted during the year		Area and number of trees planted during the year	
	Trees (in thousands)	km²	Trees (in thousands)	km²	Trees (in thousands)	km²
2008 - 2009	52,320	4,702.63	1,231	4.979	53,551	4,813.29
2009 - 2010	53,551	4,813.3	936	3.7858	54,487	4,897.43
2010 - 2011	54,487	4,897.42	278	1.1244	54,765	4,922.42
2011 - 2012	54,765	4,922.42	200	.8089	54,965	4,940.42
2012 - 2013	54,965	4,940.42	140	.5663	55,105	4,952.96
2013 - 2014	55,105	4,952.96	90	.364	55,195	4,961
2014 - 2015	55,195	4,961.05	56	.2265	55,251	4,966.1
2015 - 2016 (p)	55,251	4,966.11	65	.2629	55,316	4,971.97

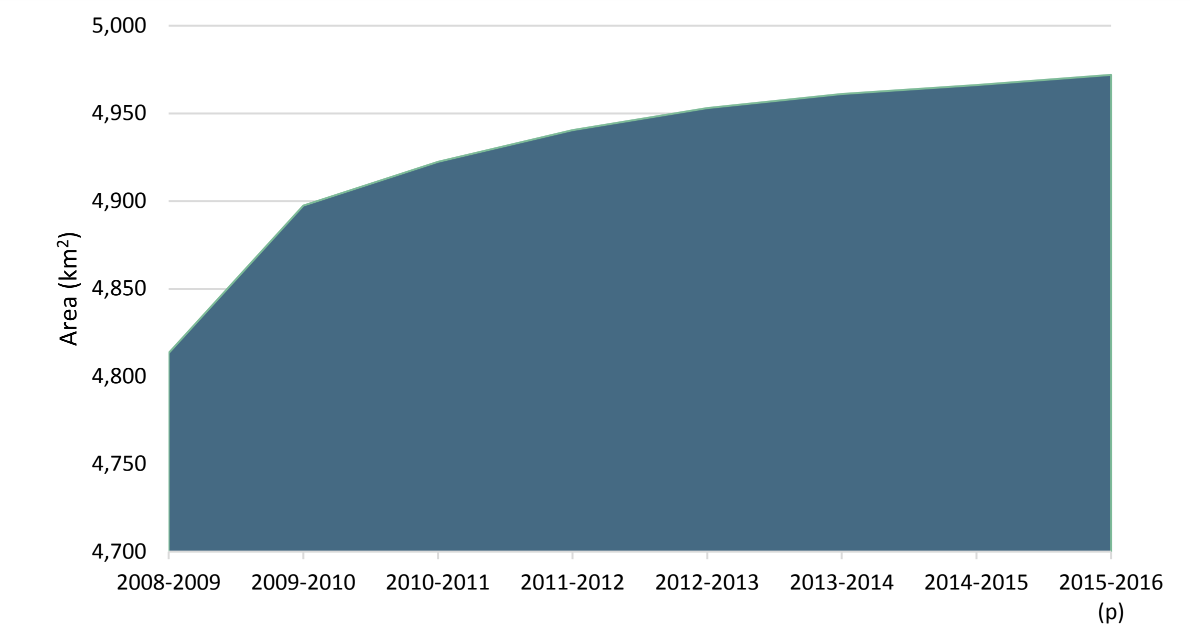


Figure 75 - Area (ha) of hardwood plantation from 2008 - 2009/2015 - 2016

Initially, forest plantations were thought to be the solution to counter deforestation in Myanmar; large-scale plantations began in 1980. Later, it was realized that such plantations impacted adversely on soil, water resources, and biodiversity. Large-scale plantations were abandoned and, instead, small-scale plantations were established as a compensatory measure (Kissinger, 2017).

If managed effectively, small plantations can have a positive benefit and assist in reducing the rate of deforestation. Plantations can remove the timber pressure on natural forests, but this does not always translate into less deforestation; in some cases, it can lead to increases in deforestation. Unfortunately, approximately 50% of plantations in the tropics are established on native forest cleared for this purpose (Chakravarty et al., 2011).

a) Local distribution of teak, hardwood, and plywood

Following the log export ban, the local distribution of teak conversion (Figure 76) and hardwood conversion (Figure 77) increased significantly.

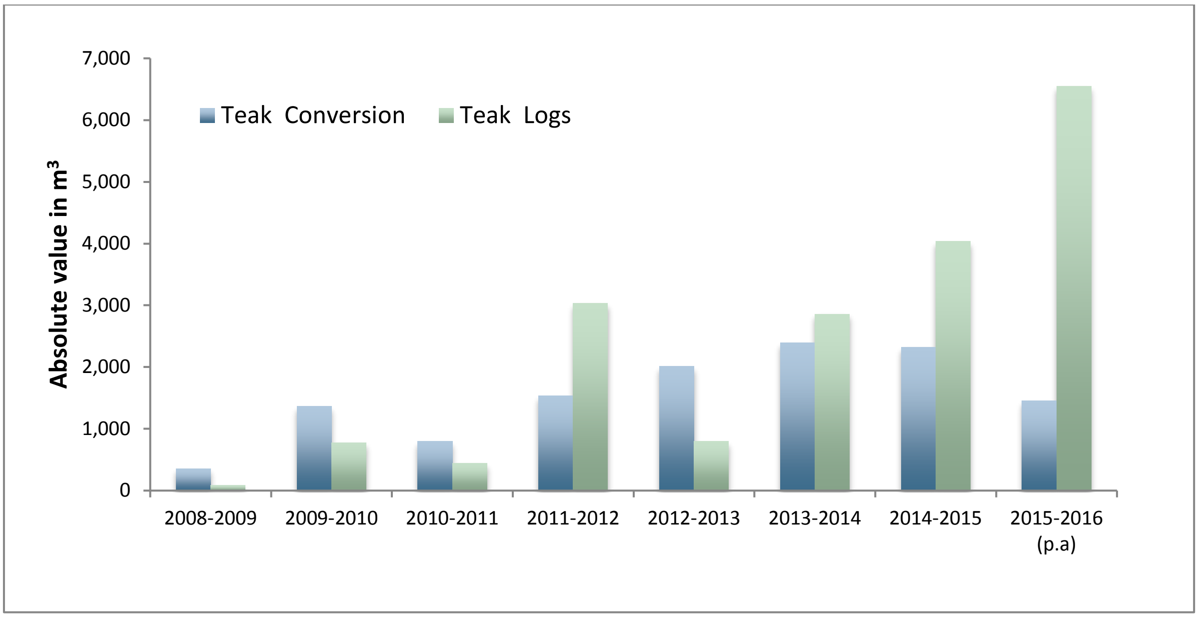


Figure 76 - Local distribution of teak from 2008/2009 to 2015/2016

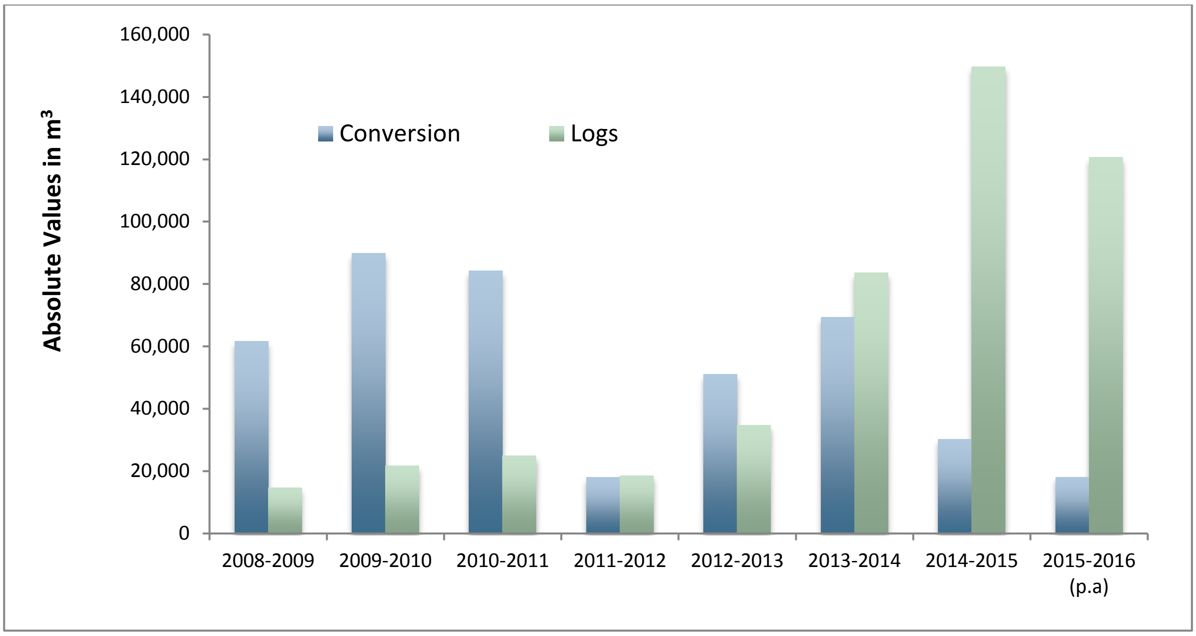


Figure 77 - Local distribution of hardwood from 2008/2009 to 2015/2016

The increased local distribution of teak and hardwood conversion does not reflect in the official data for saw mills, recutting mills, and domestic industrial mills which show a decline.

From 2000 through 2007, Myanmar exported a limited but steady supply of sawn wood to China, representing approximately 27% of total export volumes (Figure 78). However, sawn wood exports to China decreased by 62% in 2008 and have remained at reduced levels (Woods, 2013). The decline in sawn wood exports may have been one of the drivers for the log export ban. Prior to the logging export ban, high quality sawlogs were exported in log form and low-quality logs were transferred to domestic sawmills and wood processing factories (Khin Htun, 2009).

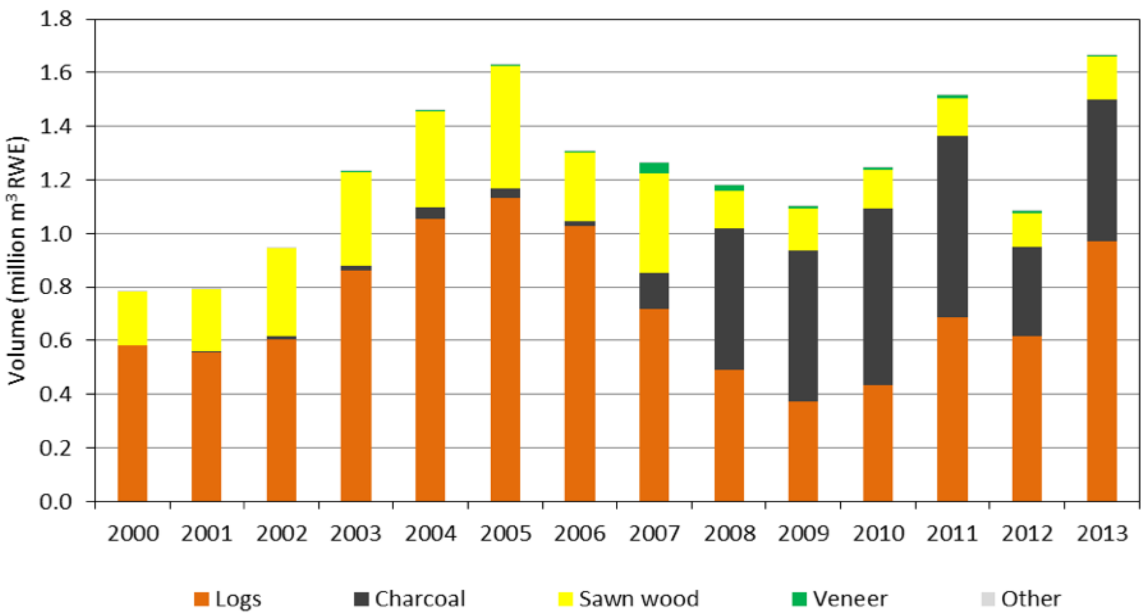


Figure 78 - Myanmar timber product exports by volume (M m3) Round Wood Equivalent

(Woods, 2013)

Under-development of wood-based industries in Myanmar is due to lack of adequate investment capital and technology. The low investment is often due to uncertainty in acquiring an adequate and steady flow of raw materials.

6.3.3 Ecosystem services

A study in 2012 found that the current annual value of forest ecosystem services is estimated to be US$ 7.3 billion (Emerton and Aung, 2013). Approximately 85% (US$ 6 billion) comes from forest ecosystem services that maintain the productivity of other sectors, add value to their output, and help them to avoid costs, losses, and damages. The study compares the costs of forest conservation and forest degradation scenarios. There are short-term gains from converting, degrading, and exploiting forests, but these gains cannot be maintained over the longer term.

Should Myanmar continue to degrade and lose its forests, its economy could incur losses (in monetary and non-monetary values) of more than US$ 17 billion by 2031 over the current situation. However, should Myanmar choose a development pathway that allows for forest conservation, its economy would benefit by an additional US$ 22 billion by 2031.

An important but less visible service provided by forests is watershed protection. Water quality and flow are highly influenced by the status of forests. Once, Bago Yoma served the purpose of watershed protection for lower Myanmar, particularly the northern part of Yangon Division, Bago Division (East), Bago Division (West), and the southern parts of Mandalay Division and Magway Divisions (IFC et al., 2017).

Another critical ecosystem service in Myanmar is the provision of freshwater resources (NBSAP, 2015). While Myanmar is a country of low water stress, it remains vital to protect the quality and reliability of freshwater resources, particularly in regions which experience long periods of drought such as the Ayeyarwady dry zone. Forests can also play a role in helping to reduce flood risk; flooding accounts for 94% of Myanmar's disaster risk and is the country's greatest source of loss (UNISDR, 2015).

6.3.4 Reforestation

In addition to commercial and industrial plantations, the FD have prioritized three zones in the Ayeyarwady Basin for reforestation (Figure 79):

1. **CDZ** - An area with desert-like formation and land degradation with rainfall of 600 mm/y. The reforestation includes agro-forestry and conservation of natural forests.
2. **Bago Yoma Zone** - Suffered from rapid deforestation with 1,933 mm/y rainfall. Reforestation effort includes substitution of shifting cultivation, Taung ya-planting (agro-forestry), community forestry, horticulture, model forests, and plantations.
3. **Mangrove-Delta Zone** - Deforestation of mangroves, livelihoods vulnerable to natural disaster with rainfall greater than 3,500 mm/y. Reforestation efforts include community forestry, livelihood improvement, cyclone shelters, income generation activities, and restoration planting.

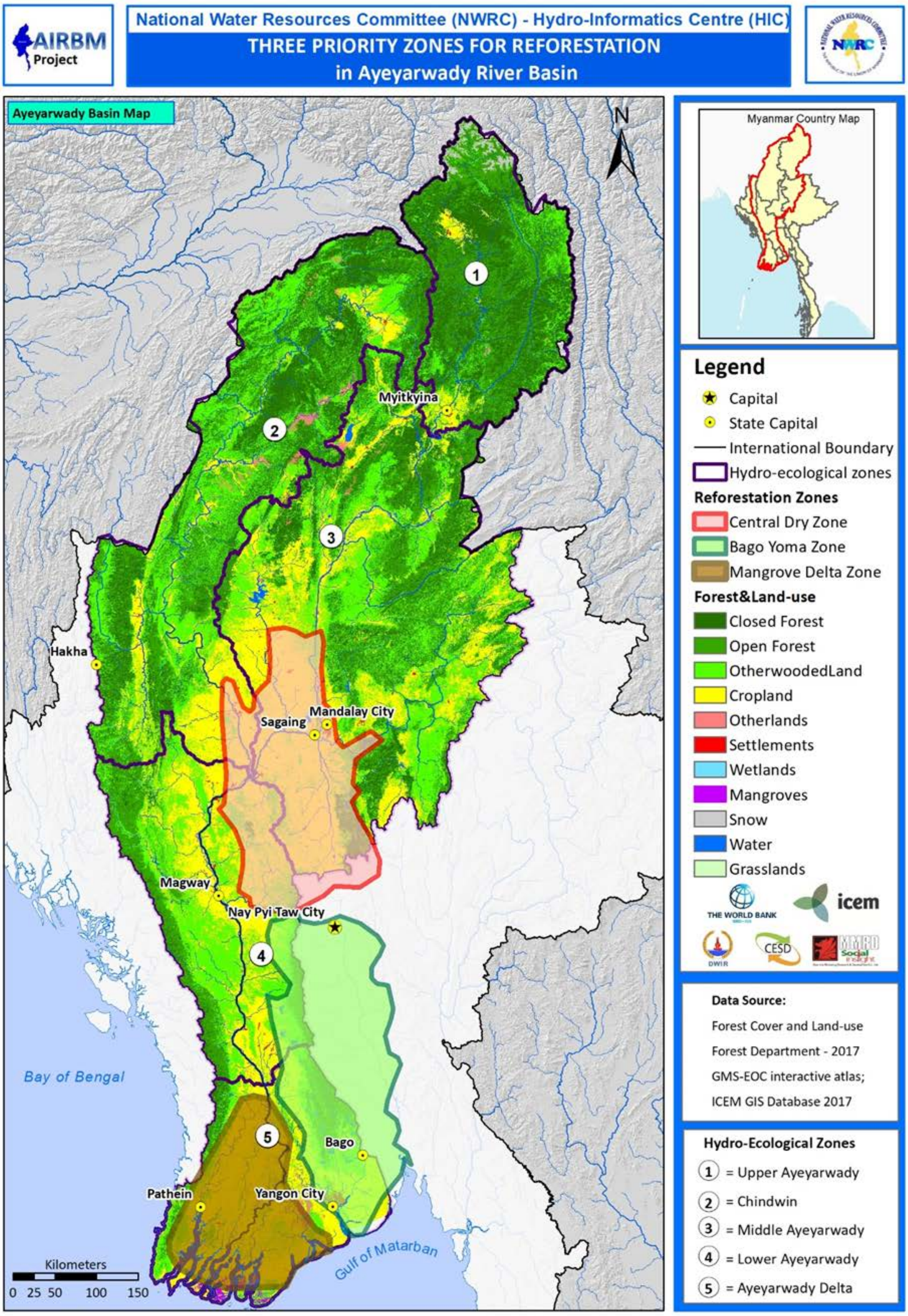


Figure 79 - Priority zones for reforestation in the Ayeyarwady Basin

The Dry Zone Greening Department was created to facilitate greening and rehabilitation activities:

1. Establishing forest plantations for local supply and greening;
2. Protection and conservation of remaining natural forests;
3. Promotion of fuelwood substitution; and
4. Developing water resources.

The comparison of land use conditions before and after thirty years of the plan is shown below in Figure 80.

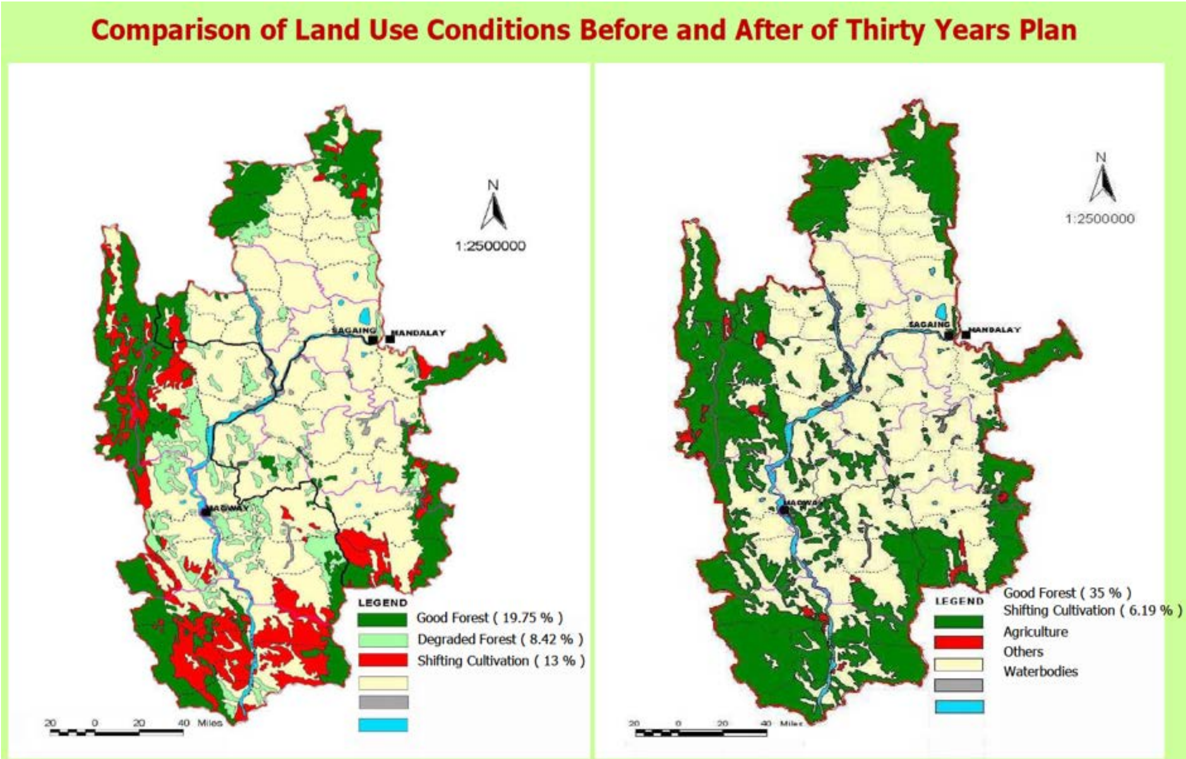


Figure 80 - Example of reforestation in the CDZ (Central Dry Zone Greening Department, 2015)

6.3.5 *Charcoal and fuelwood production*

Charcoal comprised approximately 42% of the volume traded from 2008 through 2013. Chinese import statistics indicate that the growth in Myanmar's charcoal exports reflects a trend that is also occurring across Laos, Vietnam, and other countries in the Greater Mekong Subregion.

Charcoal exports to China increased significantly between 2006 and 2008 when volumes increased by more than 2,500%. While the overall volumes have stabilized approximately 0.5 M m^3 (2013), charcoal now represents 32% of Myanmar's total timber product exports to China. Preliminary Forest Trends research suggests that this dramatic growth is driven by the use of charcoal in the smelting process for China's silicon metal industry, with a likely end use in solar panel production (Forest Trends, forthcoming 2015a). Approximately 100% of Myanmar's charcoal exports are registered in the Kunming customs district, indicating cross-border rather than overseas transportation.

Mangroves in delta areas, especially the Ayeyarwady Division, have been major sources of charcoal production for many years. Many mangroves are extinct or threatened in the Ayeyarwady Division due to over-logging for charcoal production. Other areas which are engaged in charcoal production in the Ayeyarwady Basin for commercial purposes are Bago Division, Mandalay Division, Magway Division, and lower Sagaing Division.

Fuel-wood demand is likely far higher than official supplies, but the only figures available are from the late 1990s; these estimate consumption of fuelwood for 2000 and 2005 at between 40 and 46 M m^3—much higher than the estimated renewable supply of only 24.1 m^3 (FAO, 2009). By 2009, just over 83,000 km^2 of plantations in total had been established, but only 5% (2,844 km^2) had been designated to supply the local market for fuelwood, posts, and poles. Demand for fuelwood is expected to reach 55 M m^3 of dry biomass by the year 2030 from 32 M m^3 in 2000 and 42 M m^3 in 2010. The regions that will see the greatest increases include Ayeyarwady region, Mandalay region, Bago region, Shan state, and Sagaing region.

An explanation of the use of fuelwood for energy sources in rural areas is provided in Section 8 - Energy.

6.3.6 Community Forestry (CF)

About 833.21 km^2 of CF have been established in Myanmar. The important role of community forestry as a participatory tool to achieve sustainable forest management and improve rural livelihoods was emphasized in the Forestry Master Plan of 2001 - 2002 to 2030 - 2031. The FD set the following targets to establish community forestry as an integral part of the strategy to achieve sustainable forest management:

- To make a significant contribution towards the rehabilitation of the annual deforestation of 220.18 km^2 (approximately 0.3% of Myanmar's total land area);
- To achieve 9,190 km^2 of CF by 2030 (1.36% of Myanmar's total land area); and
- To obtain fuelwood amounting to 4.13 M m^3 (25% of the total fuelwood requirement of 16.53 M m^3 at the end of 2030).

The 2016 revisions to the Community Forestry Instructions also seek to address the basic needs of timber and non-timber products for local people. The revisions allow full access to resources, including teak, allow for commercial sales, seek to create job opportunities and income for poverty reduction, to increase forest area, and to provide a perpetual supply of forest products in a more sustainable manner to support forest management and climate change mitigation and adaptation (Kissinger, 2017).

6.3.7 Livelihoods

Myanmar is highly dependent on ecosystem services and products, with 66% of the population working in agriculture, and much of the rural work force involved in natural resource-dependent activities including fishing, mining, and forestry (Emerton and Aung, 2013). National income earned directly from forest products accounts for only 15% of this estimated annual value, with the remaining 85% derived from forest ecosystem services that maintain the productivity of other sectors and help to avoid costs, losses, and damages.

Approximately 36,000 people were directly employed in the forestry sector in 2011, and broader estimates from 2009 including unreported, informal, and indirect employment suggest up to 500,000 people are dependent upon the forestry sector for employment. In 2012, approximately 520,000 forest-adjacent households were likely to depend on forestry resources for their livelihoods.

Although the relative importance of this has likely declined with rapid expansion of the services and industrial sectors, the sector remains a significant source of employment in rural areas. Forestry is also important for rural livelihoods. Many communities are dependent upon forested areas for fuelwood and small timber for construction and provision of farm implements. Timber and other forest products also represent a significant source of income for EAGs, most notably in Kachin State along the border with China.

Rural communities in the Ayeyarwady Basin depend heavily on agriculture, forestry, and fisheries for their livelihoods and food security. These trends are explored further in Section 3 - Rural Livelihoods.

6.4 Conclusions and Recommendations

6.4.1 Development issues and options

There are still extensive areas of closed (or intact) forest in the Ayeyarwady Basin, however deforestation and degradation of existing forests remain a critical issue in Kachin state, Sagaing region, and Shan states. This is mainly due to illegal logging and overharvesting of timber, which is facilitated through the development of areas cleared for plantation, agribusiness, extensive mining activities, and HP or irrigation development. Forest loss in the Ayeyarwady Basin not only presents concerns for the long-term sustainability of the forestry sector but also entails broader environmental consequences, including land degradation, erosion and soil loss, sedimentation, increased flooding, and biodiversity loss.

The difficulty in projecting trends for the forestry sector is that there are major discrepancies between national statistics and international sources. The national statistics do not include large portions of illegally exported wood and figures are derived from customs statistics from importing countries or rely on remote sensing to detect land use changes. In developing trends for the forestry sector to 2030 it can be assumed that there will be:

- Continuing development of plantations and conversion of natural forests;
- Continuing allocation of agribusiness concessions in 'unclassified' or 'wasteland' forested areas;
- Continuing forest degradation near roads and infrastructure development;
- Some declines in fuelwood demand can be expected with improved access to energy, but charcoal and fuelwood demand are expected to remain important and likely at unsustainable levels;
- Continuing unsustainable timber extraction - both legal and illegal, concentrated in areas of intact or closed forests;
- A small increase in forest cover due to reforestation in CDZ (Middle Ayeyarwady), Bago Yoma (Lower Ayeyarwady), and Ayeyarwady Delta; and
- Increased levels of local distribution of teak, hardwood, and timber products.

Teak and hardwood extraction in the Ayeyarwady Basin has declined in part due to policies banning cross-border trade and export of logs. The recent export ban is reflected in the decline in production in 2014 - 2015, however in terms of illegal logging, Sagaing region and Kachin state remain an important source of timber for the Chinese market. A boom in demand for rosewood in China has led to a significant increase in the importance of this trade, and there are concerns that rosewood could be logged to commercial extinction.

The supply of quality teak logs originating from old-growth natural teak forests in Myanmar declined as a result of the log export ban. The increased interest and investment in establishing teak plantation was a result of declining harvestable area in natural teak forests and deteriorating quality of naturally grown teak (FAO, 2015). To maintain sustainable yield of timber and forest products, natural forest regeneration and artificial forest plantation is increasing.

6.4.2 *Recommendations*

Developing a timber legality and assurance system (timber certification) is needed to ensure more sustainable harvesting of teak and hardwoods in the Ayeyarwady Basin. The area of teak plantation in the Ayeyarwady Basin has increased by from 3,341.78 km^2 in 2008 - 2009 to 3,839 km^2 in 2015 - 2016 and hardwood plantation increased from 4,813.29 km^2 to 4,971.97 km^2 in the same period. Establishing teak plantation was a result of both declining harvestable area in natural teak forests and the deteriorating quality of natural grown teak.

The log export ban has been successful in reducing the volume of teak and hardwood extracted from forests and plantations in the Ayeyarwady Basin from approximately 1,176,222 m^3 in 2012 - 2013 to 546,428 m^3 in 2015 - 2016. However, plans to establish the VPA with the EU under the FLEGT Action Plan are more sustainable options for the long term. The government joined the UN-REDD Programme in December 2011 and completed the REDD+ Readiness Roadmap in June 2013; this is another significant global initiative that enables forest conservation in Myanmar.

The local distribution of teak and hardwood conversion increased significantly after the log export ban, however the number of saw mills, recutting mills, and domestic industrial mills declined. More investment is also needed in the timber industry to drive the export of wood products, not sawn logs.

Myanmar is highly dependent on ecosystem services and products, with 66% of the population working in agriculture, and much of the rural work force involved in natural resource dependent activities including fishing, mining, and forestry. A detailed assessment of forest ecosystem services is required in the Ayeyarwady Basin. The 2012 study on forest ecosystem services generated two scenarios (Emerton and Aung, 2013):

1. **Forest conservation,** in which Myanmar chooses a development pathway that allows for forest conservation, and its economy would benefit by an additional US$ 22 billion by 2031; and
2. **Forest degradation,** in which Myanmar continues to degrade and lose its forests, and its economy could incur losses (in monetary and non-monetary values) of more than US$ 17 billion by 2031 over the current situation.

This assessment could be developed taking into account the current status of forest cover and ecosystems and be used to formulate the forest conservation strategy. The forest ecosystem assessment could be combined with a system to promote payment for ecosystem services and the green economy in the forestry sector. Case studies could also be established to review the positive impacts of reforestation in the CDZ, Bago Yoma, and Ayeyarwady Delta, contributing to the forest conversation strategy, reforestation, and watershed protection.

Myanmar is committed to increasing RF and PPF to 30% of total land area by 2030 (up from 24.5%), and 10% of land for protected areas (up from 5.75%.). This increase in RF and PPF would be roughly 40,000 km^2, which may have to come from land earmarked for agribusiness concessions. The Master Plan for the Agriculture Sector (2000 - 2001 to 2030 - 2031) developed by MOALI aims to convert 40,500 km^2 of unclassified forest or waste land for private industrial agricultural production; promoting the expansion of rubber, oil palm, paddy, pulses, and sugarcane.

Even the FD targets to achieve 9,190 km^2 of CF (1.36% of total area) and obtain 16.53 M m^3 by 2030 require analysis of how to manage these areas and include ethnic minority groups to ensure sustainable and equitable development. Further assessment is needed on the impacts of swidden agriculture on forest in the Ayeyarwady Basin.

The National Land Use Policy being drafted in Myanmar needs to be adopted in order to allocate land considering the land use of key sectors, states/regions, and both urban and rural areas. Laws and rules under the National Land Use Policy also need to be implemented to take into account the following laws:

- Forest Law (1992);
- Environmental Conservation Law (2012); and
- Vacant, Fallow and Virgin Lands Management Law (2012).

The competing interests between forestry, agriculture, mining, and HP sectors make meeting government commitments to forestry, climate mitigation, and biodiversity conservation complex. A spatial assessment is needed to define forest cover and land use that assesses sectoral and state/region planning. The future impacts on forests from the development of roads, HPPs, pipelines, SEZs, and power lines requires further assessment and spatial planning or zoning.

7 MINING

7.1 Introduction

The Ayeyarwady Basin contains a diversity of mineral deposits of economic value. Mining is an important contributor to economic production and source of employment in the basin. Due to the relative isolation of the country over the past decades, despite its rich minerals potential, the Ayeyarwady Basin, like the rest of the country remains largely unexplored. At present the basin produces precious stones such as jade, rubies and spinel, gold, copper, nickel, zinc, lead, iron, and a host of industrial minerals as well as mineral fuels (see Chapter 8 - Energy).

This chapter looks at the mineral potential and production in the Ayeyarwady Basin with a focus on the implications of development of the sector for broad-based sustainable development in the river basin. Section 2 considers the national context in terms of mineral resources and production, including the overall economic importance of the sector. Section 3 considers mineral resources and production in the Ayeyarwady Basin and established trends in the development of the sector. Section 7.4 looks at issues in the sector including those related to sector development, artisanal and small-scale mining (ASM), and environmental and social issues.

7.2 National Mineral Resources and Production

7.2.1 National context

a) Mineral resources

Myanmar's complex geology means it has potentially large and varied mineral resources throughout the Ayeyarwady Basin, many of which have yet to be thoroughly explored (Figure 79; Htun, 2014). A recent study on Myanmar's geological potential notes that the country has significant untapped potential, which could lead to huge growth in the mining sector, both through the rehabilitation of old mine workings and the discovery of new deposits (Gardiner et al., 2014). Resources include gemstones, mineral fuels (coal, natural gas, and oil), metals (iron, manganese, chromium, nickel, and molybdenum), precious metals (gold, platinum, and silver), base and non-ferrous minerals (lead, zinc, copper, tin, tungsten, and antimony), chemical fertilizer minerals (barite, fluorite, gypsum, and rock salt), ceramic and refractory minerals (clay, limestone, dolomite, feldspar, and quartz) and construction materials (granite, limestone, and sand). In terms of the availability of these resources, Myanmar is considered to have very rich deposits of jade, sapphire, ruby, and limestone; rich deposits of copper, lead, zine, tin, tungsten, gold, coal, and barites; and fairly rich deposits of antimony, silver, nickel, gypsum, iron, and manganese (Kywa Ohn MoM, undated). Myanmar hosts mineral deposits of global significance at Bawdwin (lead, zinc, and silver), Monywa (copper) in the Ayeyarwady Basin, and Mawchi (tin and tungsten; Gardiner, 2014).

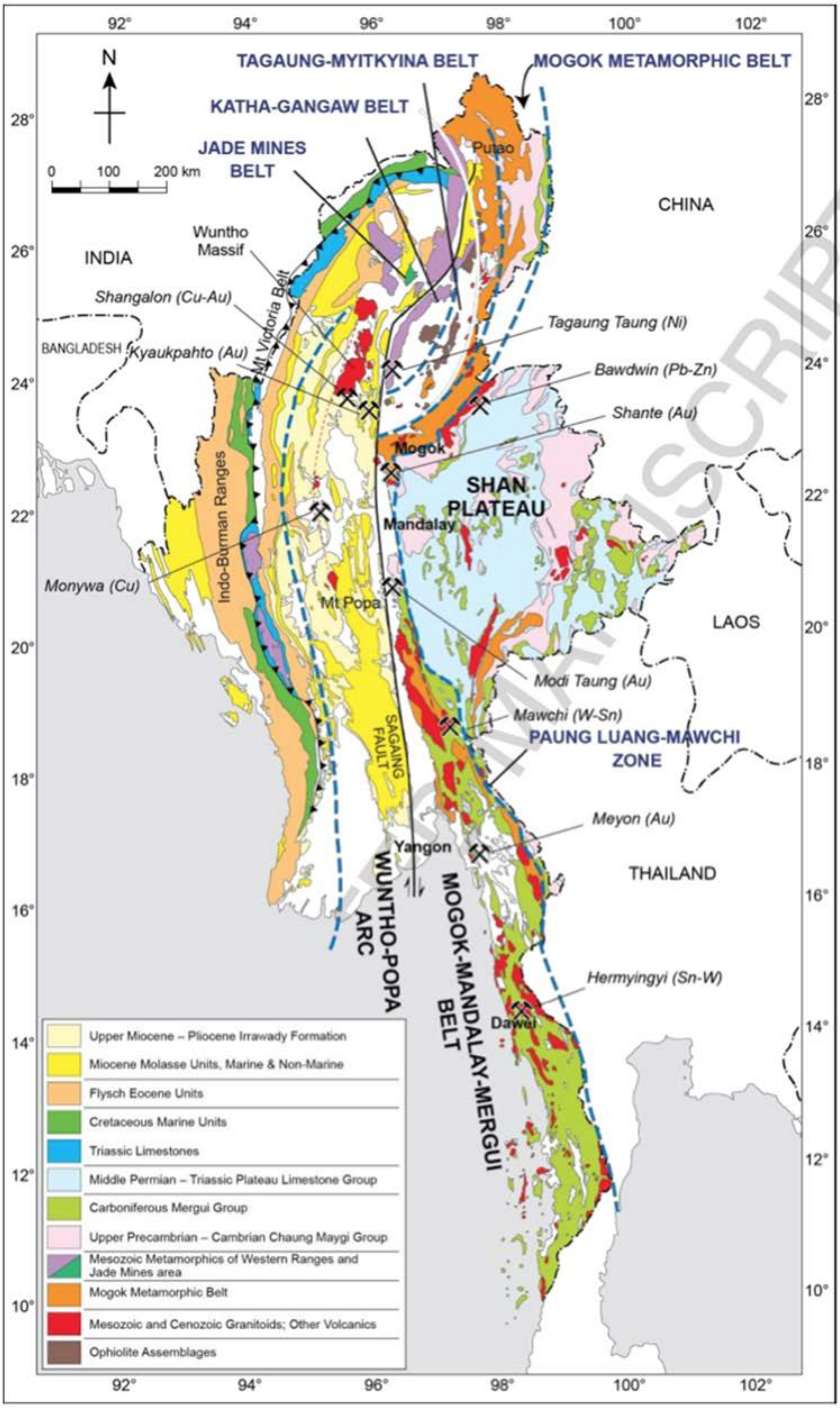


Figure 81 - Geological map of Myanmar, detailing the main geological provinces

(Gardiner et al., 2016)

Table 72 highlights the estimated extent of major mineral resources in Myanmar. Given the underdeveloped nature of most, estimates of resource potential remain speculative. Estimates of the resource potential for jade and other precious stones have not been available, although almost all of these deposits are within the basin (Irwin, 2016). As can be seen from Figure 81 and Table 72, most of Myanmar's known mineral resources are situated with the Ayeyarwady Basin. This is in part due to the favourable mineral geology of the region, but also reflects a lower level of exploration in the east of the country.

Table 72 - Main mineral occurrences in Myanmar and approximate Ayeyarwady Basin share[19]

Mineral	No. of occurrences	Resource Estimate (Mt, Possible)	Approximate Ayeyarwady Basin share	Notes
Lead-Zinc	291	44	N/K	Zinc ores of 0.3 - 36% Lead-Zinc ores of 1.06 - 5%
Lead-Zinc-Silver	>100	-	>80%	Major deposits at Bawdwin
Tin Tungsten	480	40	-	Major deposits at Mawchi and Heinda, Hermingyi
Copper	50	1,583	>80%	Copper content 0.4 - 1.5% (largest deposit at Letpadaung 1,478 mt at 0.4%)
Gold	342	66	>70%	Gold content 1.4 - 27 ppm Main mining operations at Kyaukpahto
Iron	393	495	>54%	Iron content 28 - 66%
Manganese	52	9	<15%	Manganese content 6.6 - 27%
Nickel	14	76	100%	Tagaung Taung lateritic nickel deposit 40 Mt at 2%, Mwetaung lateritic nickel deposit 36 Mt at 1.5%
Chromite	43	0.1	100%	-
Coal	300	480	46%	Mainly sub-bituminous and lignite.

b) Mineral production

In terms of production, Table 73 shows the major mineral products in Myanmar for the years 2009-2013. Myanmar produces a number of mineral commodities including non-ferrous metals such as copper, gold, lead, tin, tungsten and zinc, precious and semi-precious stones (including jade, diamonds, rubies and sapphires), as well as oil, natural gas and coal (United States Geological Survey, 2013). The country also produces significant amounts of construction materials such as cement, sand and limestone for domestic use.

Table 73 - Production of selected minerals in Myanmar 2009 - 2013

(United States Geological Survey, 2013)

Commodity	Unit	2009	2010	2011	2012	2013
Metals						
Antimony	t	3,700	5,900	7,000	7,400	9,000
Copper (mine output)	t	3,500	9,000	9,000	19,000	25,000
Gold, refined	kg	NA	NA	NA	787	893
Lead (mine output)	t	5,000	7,000	8,700	9,800	11,700
Manganese (mine output)	t	242,000	299,000	234,400	157,000	160,000

[19] These estimates are derived from Kywa Kywa Onh (undated) and may be subject to revision.

Commodity	Unit	2009	2010	2011	2012	2013
Nickle (mine output)	t	10	-	800	5,000	9,300
Silver (mine output)	kg	249	-	-	-	-
Tin (mine output)	t	1,000	4,000	11,000	10,600	45,200
Tungsten (mine output)	t	87	163	140	130	130
Zinc (mine output)	t	6,000	8,975	30,000	21,539	31,295
Industrial minerals						
Barite	t	7,623	8,975	30,000	21,539	313,295
Cement, hydraulic	t	669,941	534,034	538,000	600,000	600,000
Gypsum	t	97,518	81,051	50,000	64,079	60,510
Precious and semiprecious stones:						
Jade	kg	25,427,237	38,990,035	45,000,000	19,080,442	12,768,000
Ruby	kg	1,674,579	1,612,070	870,000	852,033	395,711
Sapphire	kg	795,228	1,311,327	1,500,000	1,351,916	1,059,559
Spinel	kg	296,956	618,730	620,000	514,052	417,441
Crude, rock salt	t	NA	NA	NA	207,261	210,000
Stone:						
Dolomite	t	4,390	3,119	2,000	170	400
Limestone, crushed and broken	1,000t	4,000	3,200	3,200	428	667

According to official figures, mining activities, excluding oil and gas extraction, accounted for 1.2% of GDP or approximately kyat 634 billion (constant 2010 prices) in 2014 - 2015. This represents significant growth in the sector, with average real growth rate in value added at approximately 19.6% per year for the last 15 years. The mining sector is an important source of export earnings accounting for approximately 12% of exports by value in 2014-2015. Jade exports accounted for approximately 8% of this figure (World Bank, 2016c). Many commentators have noted that figures on mining and mineral extraction activities are *highly* unreliable. Production and export figures do not, by and large, take into account in-country stockpiling, illegal and quasi-legal mining operations and a large black market (Global Witness, 2015).

Considering the potential of the sector, mining has attracted relatively little foreign investment. Between 1988 (when foreign investment was enabled by new legislation) and 2015, only US$ 2.87 billion was invested in the sector, less than 5% of all FDI. This remains relatively low with the sector attracting only US$ 6.26 million in 2014-2015 out of a total across all sectors of US$ 8 billion. Concerns about the investment climate for mining activities, and especially high-risk exploration activities are preventing higher levels of investment.

7.3 Mineral Reserves and Production in the Ayeyarwady Basin

7.3.1 *Mineral reserves in the Ayeyarwady Basin*

As noted above, the Ayeyarwady Basin hosts significant geological potential. A detailed breakdown of known mineral deposits in the basin has not been available. The available data on the estimated share of the Ayeyarwady Basin in national known reserves is presented in Table 1 above and related notes. This aside it is worth stressing that the actual extent of mineral reserves is currently uncertain as the Ayeyarwady Basin, like much of the country, is under-explored.

Nevertheless, the broad characteristics of economically important mineral reserves can be described (Figure 89 and Figure 91). The Ayeyarwady Basin holds all Myanmar's jade reserves located in the Chindwin River Basin in the north of Sagaing Region at Hpakant and in Kachin state at Hkamti. To the north east of Mandalay region, the Mogok area holds most of Myanmar's gemstone tracts, producing rubies, sapphires, spinel, tourmaline, topaz, garnet and moonstone among other things. Significant gold deposits are scattered across the north of the basin, with placer deposits found in many of the rivers of the Upper Ayeyarwady, Middle Ayeyarwady and Chindwin basins. Significant in situ gold deposits are located at Kyaukpahto, Sagaing region, Phayaungtaung and Kwinthonse in Mandalay region and Namma- Kangon in Kachin State.

Occurrences of copper are found in the southern part of the Chindwin River Basin, with significant deposits of porphyry hosted copper extending from Shangalon, Kyesin Taung, and Sabe Taung to Letpadaung in the south of the Chindwin Basin. Lead-zinc-silver deposits are also important with larger deposits in Kyadwinye in Mandalay Region, Panwa in Kachin State, and Bawdwin in northern Shan State. Nickel is found in Mwetaung, Indawgyi, and importantly Tagaung Taung in Sagaing Region. There are also large potential iron ore deposits in Kachin State at Kathaing Taung and Taung Nyo Taung as well as smaller deposits at Lamaung and Sanleik also in Kachin State, and Kyatwinye and Inya in Mandalay region. Aside from these major deposits there are also smaller occurrences of chromite, manganese, gypsum, limestone, barite, bauxite, and phosphate in the Ayeyarwady Basin (Kywa Kywa, undated). As noted in the section on energy (Section 8) the Ayeyarwady Basin is also home to significant fossil fuel deposits.

Box 3 - Large uncertainties in evaluating the economic importance of mining activities - the case of jade mining

Hpakan, in the north of the Uyu River Basin is the centre of the jade mining industry in Myanmar. The sector is notorious for the semi-legal or illegal extraction and export of jade. Officially, all marketed jade must be sold through Myanmar Gems Emporium. However, alternative figures suggest that the precious stone is subject to wide-spread smuggling across the border to the PRC, the largest global consumer of jade.

Official figures for 2013 - 2014 show exports of all minerals, including jade, worth approximately US$ 1.15 billion. Figures from Myanmar Gem Emporium indicate jade sales in the same year of US$ 3.4 billion, roughly three times official export figures (Global Witness 2015). However, estimates based on Chinese important data from the UN Comtrade database, recorded jade imports worth US$ 12.3 billion, an estimate that is similar to that generated by research performed for the EITI, suggesting that officially traded jade (and gems) account for approximately only 20 - 40% of the actual trade. Global Witness (2015) estimates that the trade officially recorded by the Chinese authorities only accounts for approximately one third of the actual border trade, and that the actual value of the trade is likely be in the order of approximately US$ 30 billion.

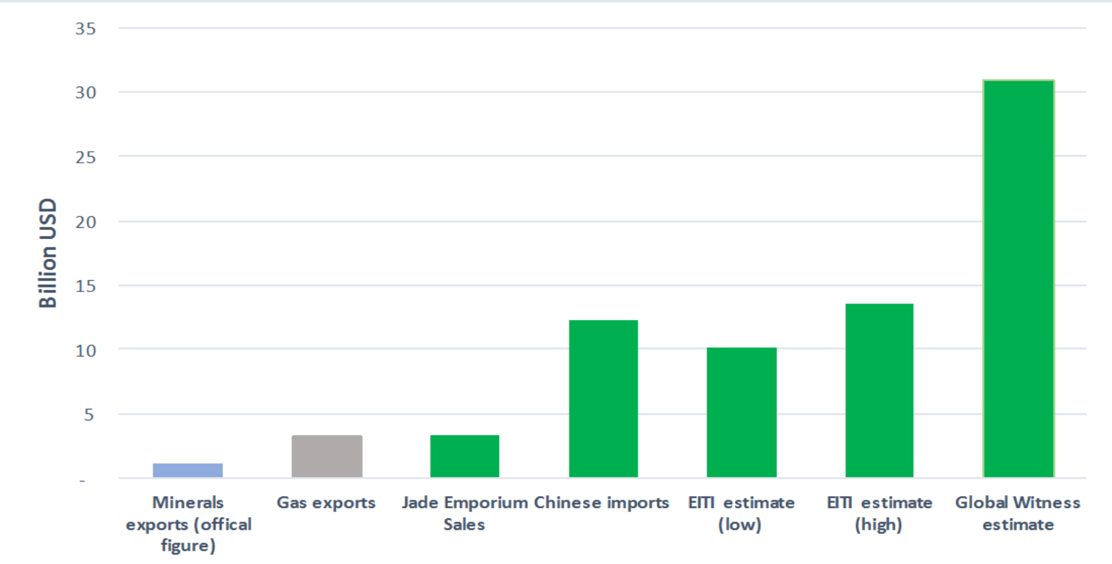


Figure 82 - Differing estimates of value of jade exports in 2013-2014 context

(Department of Planning, World Bank 2017b, IMF, 2015; Global Witness, 2015; Irwin, 2016)

These estimates are shown in Figure 2 alongside the value of gas exports for comparative purposes. It should be noted that if the Global Witness figure is correct this would suggest that the value of the jade sector would be approximately 46% of GDP in 2014. Even if this figure is inflated, the Chinese import figures suggest that official figures grossly underestimate the value of the jade sector. It is likely that the prevalence of smuggling also extends to other valuable mineral commodities, such as gems and gold, although figures have not been available relating to these commodities.

7.3.2 Major minerals produced in the Ayeyarwady Basin

As with the figures on mineral reserves, disaggregated figures for mineral production for the Ayeyarwady Basin have not been available. It is clear in some circumstances the Ayeyarwady Basin accounts for all or most of national production, as is the case for jade, gemstones, copper, onshore oil and gas, ferro-nickel, zinc and lead. For other more widely distributed and mined mineral products it is not possible to arrive at a figure. Figure 81 gives the sites of major mines in the Ayeyarwady Basin.

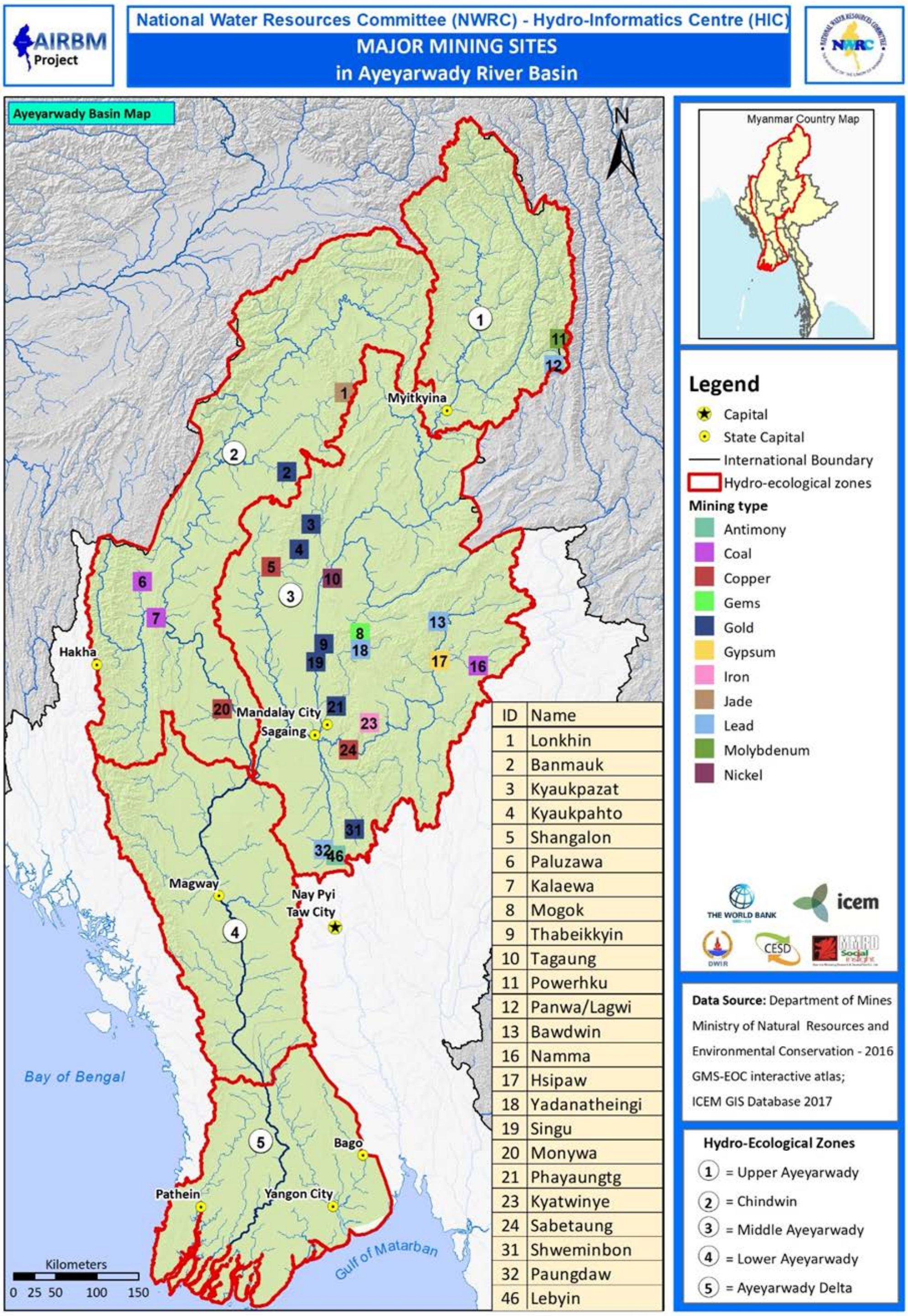


Figure 83 - Major mining sites in the Ayeyarwady Basin

(Kywa Kywa, undated)

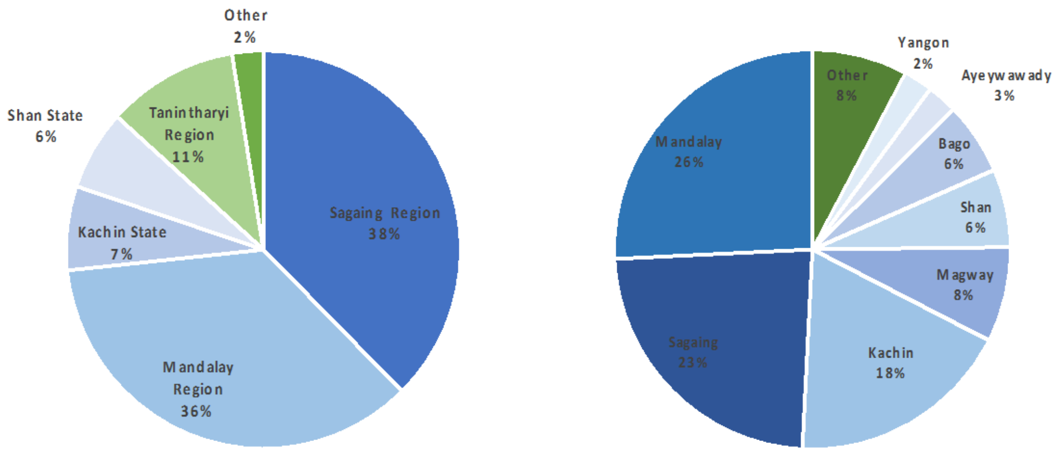


Figure 84 - Share of mines by state/region (a) share of mining employment by state/region (b) in 2014

(Department of Mines [DoM]; UNFPA 2014)

The DoM figures show a significant increase in the number of mines between 1995 and 2010, reaching a peak of almost 3,000. This is probably a result of progressive liberalization of the licensing and investment regime over this period. From 2010 the number of mines has decreased significantly to 936 mines by 2014 in Ayeyarwady Basin regions and states. It is not clear what caused this decline in mine numbers.

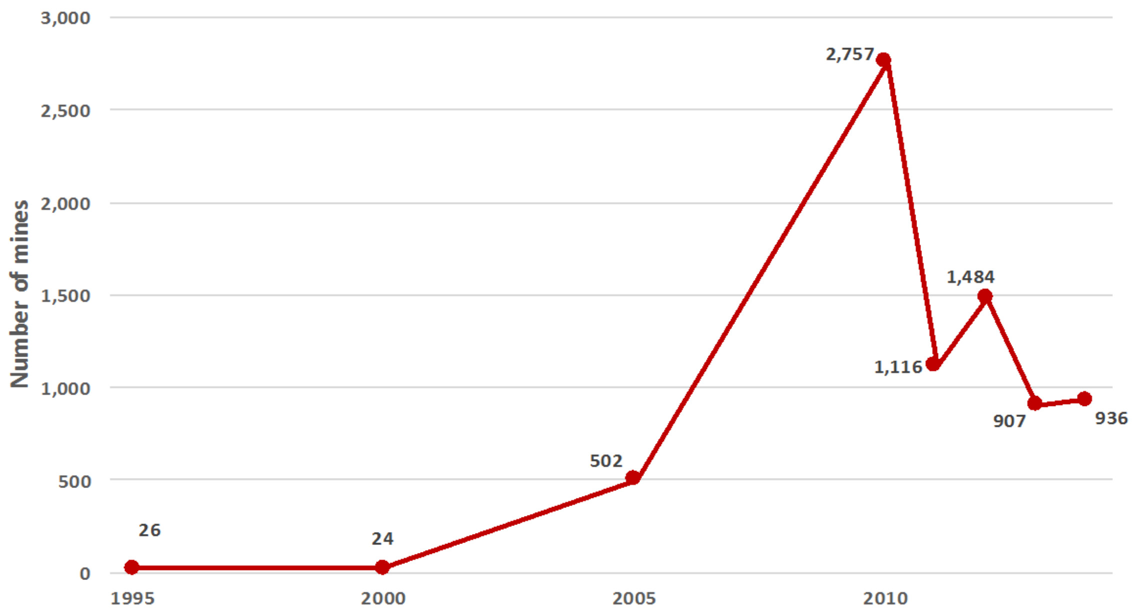


Figure 85 - Number of mines in Ayeyarwady Basin states/regions[20] 1995 - 2014

(DoM)

However, the growth in the number of mines is consistent with production figures and figures relating to the share of GDP attributable to mining activities. This also accords with the finding of other commentators who have noted the expansion of mining (particularly of gemstones) in recent years (e.g., Irwin, 2016). Anecdotal reports have also suggested that there has been an increase in artisanal and small-scale (ASM). These observations also accord with available GIS analysis reported in Section 7.4.2.

[20] Including Sagaing region, Kachin state, Mandalay region, Bago region, Magway region, Shan state, Chin state and Ayeyarwady region.

7.3.3 Major minerals produced in the Ayeyarwady Basin

A range of minerals are produced in the Ayeyarwady Basin, including jade, gemstones, gold, copper, nickel, lead, limestone, and other aggregates. As we have emphasized, while this, together with mineral fuels extraction, comprises the bulk of mining activity in the Ayeyarwady Basin, extraction of other mineral is also important. This includes the production of molybdenum, gypsum, iron, manganese and bauxite among other things. However, data on these activities has not been available. In the following section we discuss the main mineral extraction activities in the Ayeyarwady Basin, highlighting key issues relating to the activity.

a) Jade

Jade is found predominantly in the Hpakant area of Kachin State as well as Mohnyin, and also in Hkamti Township in Sagaing region in the Chindwin Basin. It is estimated that 90% of the world's jade is mined in the Ayeyarwady Basin at Hpakant and sold to the rapidly expanding Chinese market. It should be noted that official figures on the trade in jade have shown a decline in 2015 and 2016. The reasons for this are not clear but may point to a reduction in production due to renewed conflict in jade producing areas and reduced demand in China. It may also be related to government policy to decline jade mining concession agreements. While this may not have resulted in an actual decrease in jade mining activity it may have resulted in a decline in the amount of jade going through official channels (see Box 3). This decline may also be reflected in the reduction of the number of mines in Sagaing region from 402 in 2010, to 220 in 2014, and also the decline in officially recorded jade production (Figure 86). Nevertheless, despite these declines there were still 18,248 valid jade production permits in force in 2016. Considering the observed increase in mining activity (see Figure 87), it is likely that either more jade is being stockpiled by producers than previously, or there has been a substantial increase in the illicit trade in jade over recent years.

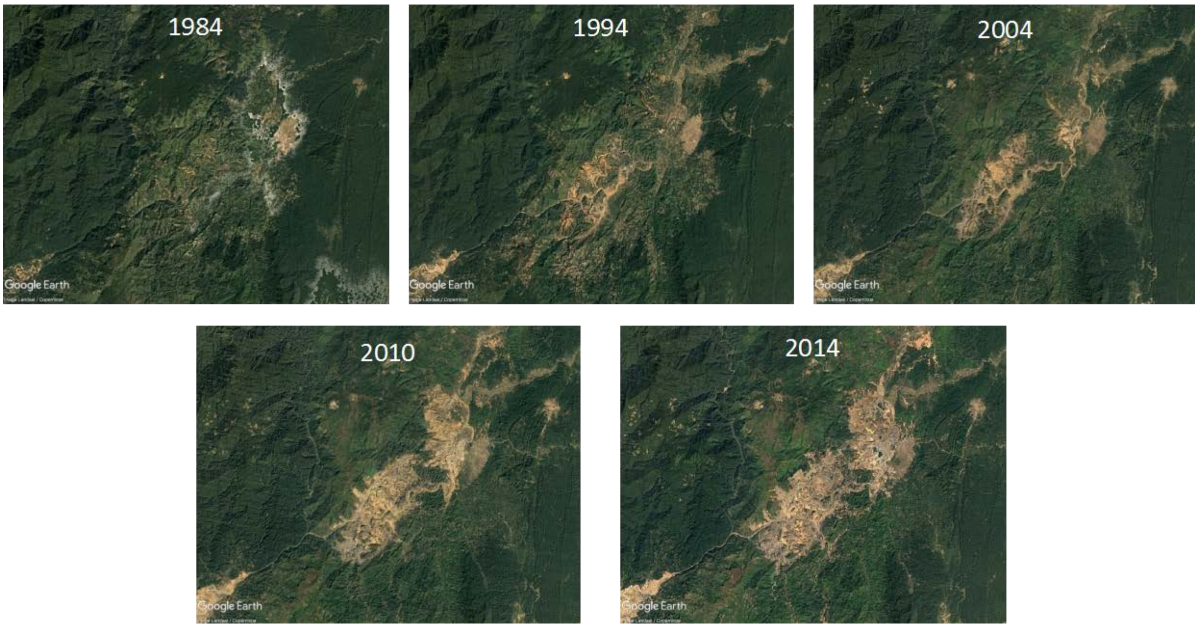


Figure 86 - Development of jade mining Hpakant, 1984 - 2014

(Google Earth, 2017)

Jade mining consists of removing the overburden from the jade bearing rocks through the use of heavy machinery, blasting, and bulldozers. The jade bearing rocks are extracted and undergo an initial sorting. Waste material is discarded either at waste dumps or in nearby rivers. Jade rocks and boulders are further sorted on site, or taken to a wash-plant for processing, after which waste materials are removed and dumped. Heavy machinery is increasing important in jade mining (Irwin, 2016). Since approximately 2014, the scale of jade mining has increased significantly, with larger, more powerful machinery being used in production. Nevertheless, there is still a heavy reliance on hand pickers, who search through the waste material to find valuable stones. Estimates suggest that in dry season the number of hand-pickers in the jade mining areas is approximately 300,000. This is in addition to approximately 100,000 formal employees of jade mining companies.

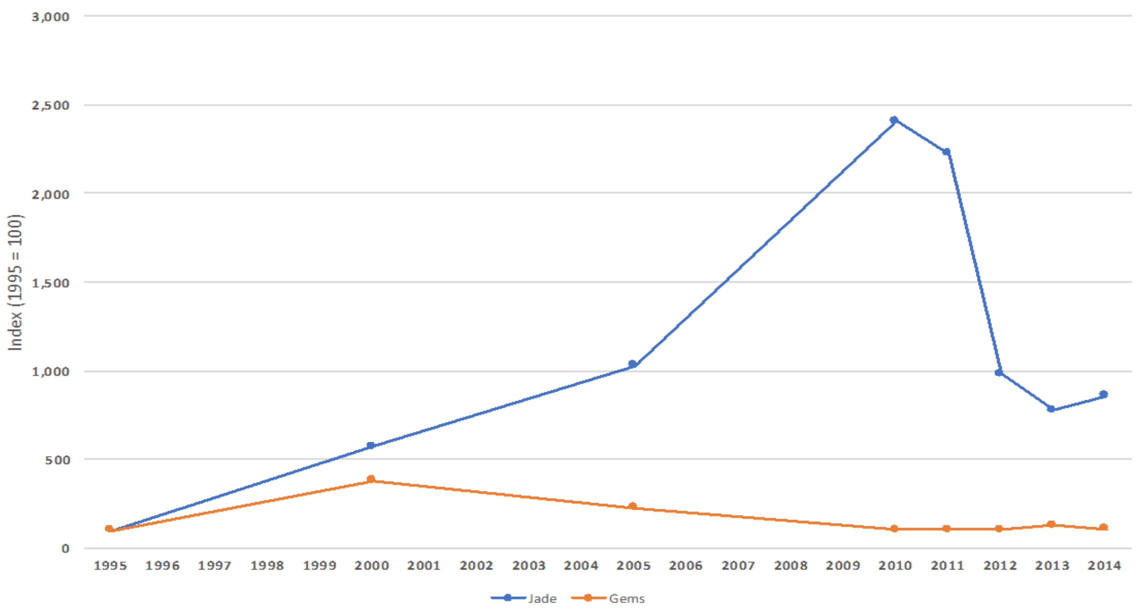


Figure 87 - Jade and gemstone production in Myanmar 1995 – 2014

(DoM)

Hand-pickers are typically employed indirectly by the site managers. They live on or near site in very poor conditions with limited access to amenities. Working conditions are also extremely hazardous with numerous deaths occurring over recent years due to landslides at the waste dumps where they work. Drug abuse is also a significant issue at the mining camps. The working conditions of hand-pickers, the environmental damage caused by jade mining, and the loss of government revenue due to smuggling are increasingly critical issues for the jade sector.

b) Rubies and other gemstones

While gemstones are found in other locations in Myanmar, the Mogok Valley, approximately 200 km northeast of Mandalay region, has long been the source of abundant gemstones including rubies, sapphires, spinel, peridot, and moonstone. The Mogok tracts are notable not only for the rich variety of gems which they supply, but also for the high quality of many of the gemstones sourced from this location (Irwin, 2016). Rubies in particular are known for their high quality and fetch a premium on international markets.[21] It is estimated that round 80 - 90% of the world's ruby supply comes from Myanmar, and the bulk of that from the Mogok area. As of 2016 there were 3,144 production permits in place (Irwin, 2016). Ali (2016) reports 1,000 - 1,200 mining operations in the stone tract.

Mogok's gemstones occur in metamorphosed, crystalline limestone/marble. In situ deposits are mined directly from the host rock by blasting tunnels and deep vertical shafts into the rock. The rock is extracted, mechanically crushed and sorted to extract the gemstones. Secondary, alluvial deposits of gemstones also occur where the gemstones have been eroded out of the host rock and carried through water courses to be deposited along with other alluvial material along valley floors. The alluvial gem-bearing layer (byon) is 1 - 2 m thick, and lies below 5 - 10 m of overburden on the valley floor. Once sufficient byon is collected, it is taken for sorting. This is done either by traditional panning or at a mechanized wash plant; in both cases the heavier coloured stones are separated from the lighter waste. Finally, artisanal miners also pick through waste heaps looking for gems. In recent years the more easily accessible placer deposits have become depleted and production increasingly relies on mining from host rocks (Ali, 2016). There is some evidence to suggest that this has led to the relative decline of ASM in the area, as hard rock mining is generally done by larger mining companies.

[21] According to Irwin (2016) a good quality untreated Mogok ruby of good colour and clarity can fetch US$ 80,000 a carat at auction.

This is also evidenced by reports of out-migration from the area. In 1992, there were 200,000 estimated immigrant miners working in Mogok and a further 200,000 resident in the town (Kane and Kammering, 1992). More recent estimates suggest an itinerant mining population of approximately 100,000, while the population in Mogok Township was reported to be approximately 167,000 people in the 2014 census. Some reports suggest that diminishing ASM opportunities are leading to a decline in the local population.

c) Gold

Gold mining is also widespread in the Ayeyarwady Basin. Despite the prevalence of gold mining in the basin, up-to-date literature on the scale and location of gold mining is limited. Most available information is from Civil Society Organizations and press reports. Based upon this fragmentary evidence it is clear that gold mining remains an important economic activity in the Ayeyarwady Basin, with considerable ASM gold taking place throughout the basin.

Gold mining broadly consists of either mining of alluvial gold, placer deposits or the mining of hard rock ore. ASM predominates in the mining of alluvial deposits as these are easier to access. Alluvial gold mining can be conducted using relatively simple methods including gold panning, sluicing, or the construction of small shafts and tunnels to extract gold bearing alluvium. Hydraulic mining is also commonly used. In this process, high-pressure jets of water are used to break-down alluvial deposits and form a slurry, which can then be passed over a sluice to separate any gold. For in-stream alluvial deposits, bucket-dredging and suction dredging rigs mounted on bamboo rafts or small boats are common. Whereas small-scale extraction using panning and shaft-and-tunnel approaches causes relatively little immediate environmental impact, the use of hydraulic mining can leave large areas stripped of vegetation and top-soil, and dredging can affect aquatic habitats (Myanmar Centre for Responsible Business [MCRB], 2016; Kachin Development Networking Group [KDNG], 2007). Gold mining from deposits in situ takes place in three main locations in the Ayeyarwady Basin: Kyaukpahto gold mine situated in Kawlin Township, Sagaing Division; five mines located at the Modi-Momei work site in Yamethin Township Mandalay Division; and Phayoung Taung gold mine in Patheingyi Township Mandalay Division (U Kyaw Thet, 2012). Smaller scale mines are also common throughout Mandalay region, Sagaing region, and Kachin state. The process of hard rock mining involves open pit and shaft mining by which gold bearing rock is extracted, which is crushed and processed to remove the gold.

Gold mining typically involves the use of mercury or cyanidation to allow the removal of gold from waste products. Mercury forms an amalgam with the gold, which evaporates when heated, leaving the gold behind. Cyanidation is safer, and produces a higher gold yield if controlled. This process is illegal, and is conducted only at a few large gold mines which have received exemptions. By and large for ASM operations the use of mercury is ubiquitous (MCRB, 2016). The high levels of mercury use in the extraction of gold pose serious environmental issues (see Section 7.4.3 below).

d) Copper

Myanmar's only copper mines are situated in the Monywa District of Sagaing Region close to the Chindwin River. There are four large copper deposits in the Monywa District situated in hills that rise out of the Chindwin floodplain. The deposits have been developed as two linked mining operations, the Letpadaung and S&K copper mines. The three smaller deposits are adjacent to each other and have been developed as the S&K mine since 1978. Letpadaung is the largest of the four deposits accounting for 75% of total copper reserves and is expected to produce 100,000 t of cathode copper when fully operational. The mines are operated by the Wanbao Mining Copper Ltd. company, in a JV with the Union of Myanmar Economic Holdings Ltd. While still under construction, operations started in 2016; according to industry sources, this project is the 'only modern mining operation in the country' (Reynolds, 2014).

Processing the copper requires first the removal and disposal of any overburden. Following this ore is extracted. Acid is then used to leach the copper from the ore. This is then further treated creating a solution from which the copper can be removed via electrolysis.

There are considerable environmental risks associated with the project, including those relevant to the disposal of waste, in particular the acidic tailing which have a high concentration of heavy metals. The plant is in a seismically active area and stands on the Chindwin floodplain. It is also close to local communities with no buffer zone. Because of these environmental concerns and issues related to involuntary resettlement and compensation for land and crops lost to the mining development, the project has been controversial with numerous confrontations between local communities and the authorities (Amnesty International, 2017).

e) Nickel

Myanmar's only nickel mining operation is situated at Tagaung Taung, Htigyaing Township in Sagaing Region. It is estimated that the lateritic nickel deposits with an average nickel content of approximately 2% contain approximately 800 kilotonne of nickel. The mine is operated by a JV between Taiyuan Iron and Steel Group and China Nonferrous Metal Mining & Construction who invested $870 million in the project (China Nonferrous Metal Mining Group, 2017). The project has been operating since 2011 and is scheduled to continue until 2031, with an annual production capacity of 85,000 t of ferronickel, containing approximately 22,000 t of pure nickel (People's Daily, 2010). The mine and smelting plant currently employ approximately 2,000 workers, 1,600 from local workers and 400 expatriate Chinese workers (The Myanmar Times, 2016). The plant obtains its power supply from the Shweli 1 HP plant; 100 MW (or a quarter of domestic capacity) is allocated to the mine and connected via 230 kilovolt (kV) power line.

Figure 88 - Tagaung Taung nickel mine and smelting plant

(Google Earth, 2017)

As with other mining projects, this large-scale open-cast project poses problems related to the management and disposal of waste materials including slag, mine tailings, mine drainage, erosion, and biodiversity loss. In addition to environmental concerns the development of the project has been plagued by issues related to involuntary resettlement and the loss of land. There remain unresolved issues which are the focus for local community protests (The Irrawaddy, 2017).

f) Lead and Zinc

The Namtu Bawdwin Mines are situated on an unusual lead-zinc-silver deposit. In 1938, the Bawdwin reserve was estimated at 10.8 Mt at 22.8% lead, 13.9% zinc, 1.05% copper, and 670 grams of silver per ton (TND, 2016). Prior to the Second World War they were the world's largest source of lead, and one of the world's largest sources of silver. Bawdin underground mine had its own concentration plant for upgrading of sulphide ores of lead, which went to the smelter in Namtu Town to produce refined lead and refined zinc and silver concentrates. Currently, the open-cast mine remains in operation but the other mining operations have been mothballed since privatization in 2010 (The Irrawaddy, 2015). Zinc-rich slags leftover from the processing of ores for lead located in Namtu Town (Figure 89) are being reprocessed by a Chinese company (Myanmar Apex) which is processing 50,000 t annually and exporting zinc oxide to a smelter in Yuanan. There remains an estimated 2.3 Mt of slag with a 17% zinc content (TND, 2016). There are other privately-owned lead and zinc mines in the same region although data on these has not been available.

Figure 89 - Namtu zinc slags (a) and Bawdwin lead-zinc-silver mine (b) in western Shan State

(Google Earth, 2017)

g) Sediment mining

Sand mining has been widespread on major rivers and beaches throughout the Ayeyarwady Basin. Up and down the major rivers of Myanmar sand dredgers are a common sight. Moreover, judging by the experience of other countries in the region (notably Vietnam, Cambodia, and Indonesia) demand from every sector can be expected to increase. The regulatory environment and enforcement are weak; although the central government has banned sand mining in Yangon due to concerns relating to environmental impacts, this has simply displaced much the extraction activity to further upstream.

There are no figures on domestic demand, but based on domestic cement demand of 8 Mt in 2016, domestic sand demand in the region of 64 Mt is feasible.[22] With burgeoning demand for construction materials domestically and high levels of regional demand - particularly from China and Singapore - the market will continue to drive an expansion in sand mining.

As transportation constitutes a large share of the cost of sand, extraction tends to be concentrated as close as possible to the sources of demand. This typically means urban areas where most construction takes place. Moving large quantities of sand and gravel from the same location can quickly alter channel morphology, which can have impacts at the site and downstream (these may include impacts on bank stability, increased erosion around instream infrastructure, and loss of habitat). Sediment mining is discussed in greater detail by SOBA 3; a case study of the demand side of sediment mining is presented in Chapter 12.

h) Limestone

Growing demand for building materials is also reflected in limestone production, which is notable mainly for its growth since approximately 2010. This increase also reflects the increase in domestic cement production for which limestone is the major ingredient (Figure 90). There is limited disaggregated national data available to enable the identification of limestone mining activities in the Ayeyarwady Basin. However, DoM data from 2015 on large mining concessions identified 32 large limestone mining concessions in the Ayeyarwady Basin out of 42 nationally, suggesting the basin likely accounts for the lion's share of production. These were situated throughout the basin in Ayeyarwady region, Sagaing region, Magway region, north Shan State, and Kachin State, although 26 of these large-scale concessions were concentrated in Mandalay Region.

[22] This is based on the assumption that most sand demand comes from construction demand for concrete, a typical mix of which would be one part cement to eight parts sand. This is a conservative estimate as it does not take account of sand demand for other uses such as asphalt, additional construction uses, and industrial purposes.

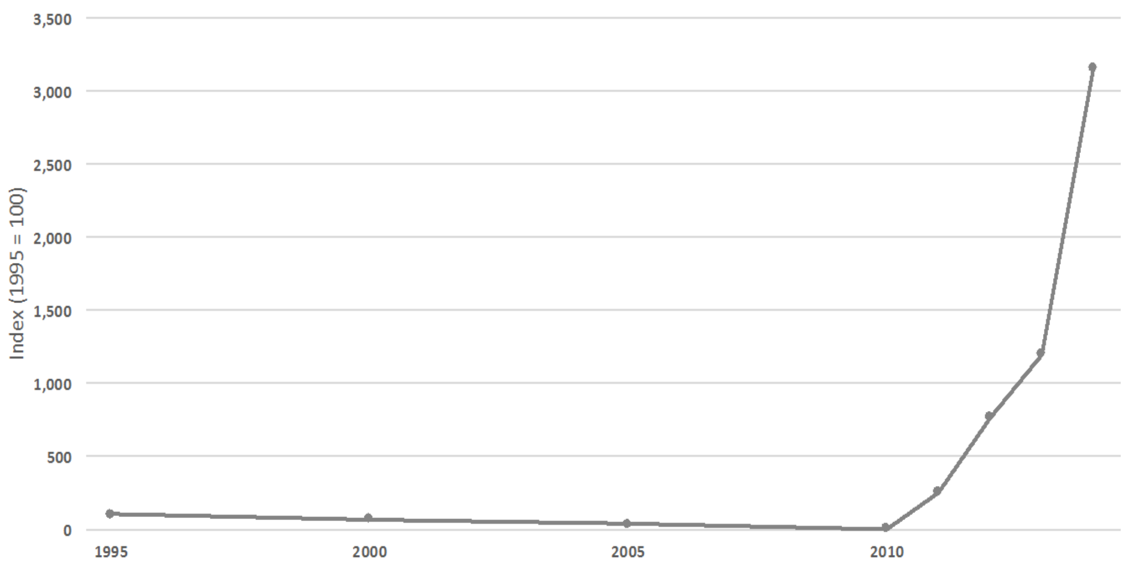


Figure 90 - National limestone production 1995 – 2014

(DoM)

Environmental impacts associated with large-scale limestone extraction include deforestation, dust creation, noise, and vibration (MCRB, 2016). Limestone is not as often associated with the other minerals considered above. However, slaked lime is used in the production of gold and the small-scale processing of this involves considerable fuelwood use which can be an important local cause of deforestation (MCRB, 2016).

7.3.4 Drivers of mining investment and activity in the Ayeyarwady Basin

Mining is not a new activity in the Ayeyarwady Basin. The mining of gold, gems, and jade has been an important industry for centuries. Recent years have reportedly seen an expansion of jade and gem mining, although the proximate cause for this is not immediately obvious. Anecdotal evidence suggests that in part, the expansion may be due to a perception that legislative and policy changes in the sector may in the future prevent incumbents from accessing these resources on such favourable terms - thus leading mining companies to extract all they can while conditions are still favourable. An additional factor may be the opening up of the country to international markets providing both easier access to international markets for gems and jade, and enabling investment in production in the sector.

More generally, outside the gems and jade sub-sector, the expansion of the mining sector seems to have been driven by both increasing demand and increasing opportunity in the sector. The details of demand growth vary greatly depending on the mineral in question. The extraction of limestone and aggregates has been driven by domestic demand in the construction industry. The development of gold and base metals mining has responded both to international market conditions and to increased foreign investment. A key factor in international demand has been rapid economic growth in China; indeed Chinese companies figure large in the development of the sector over the last decade, with the large projects at Tagaung Taung, Namtu-Bawdwin and Letpadaung all developed together with Chinese companies.

In general, the long-term structural causes of growing demand are unlikely to change. Although given the risky nature of mining exploration and development, and the consequent cost-sensitivity of the sector, development and production are likely to experience important fluctuations in the short and medium term.

7.3.5 Extent of mining in the Ayeyarwady Basin between 2002 and 2014

As noted above, due to the large scale of unofficial mining activities in the Ayeyarwady Basin understanding the extent, impact, location, and importance of mining here requires alternative data sources to those available from DoM. Recent GIS analysis using remote sensing data, has enabled the identification of areas of surface disturbance due to mining operations (Connette et al., 2016). This provides a good indicator of the extent of mining in the basin and how it has changed between 2002 and 2015.

As can be seen from the national figures, the basin accounts for approximately 87 - 88% of mining activity (Figure 91).

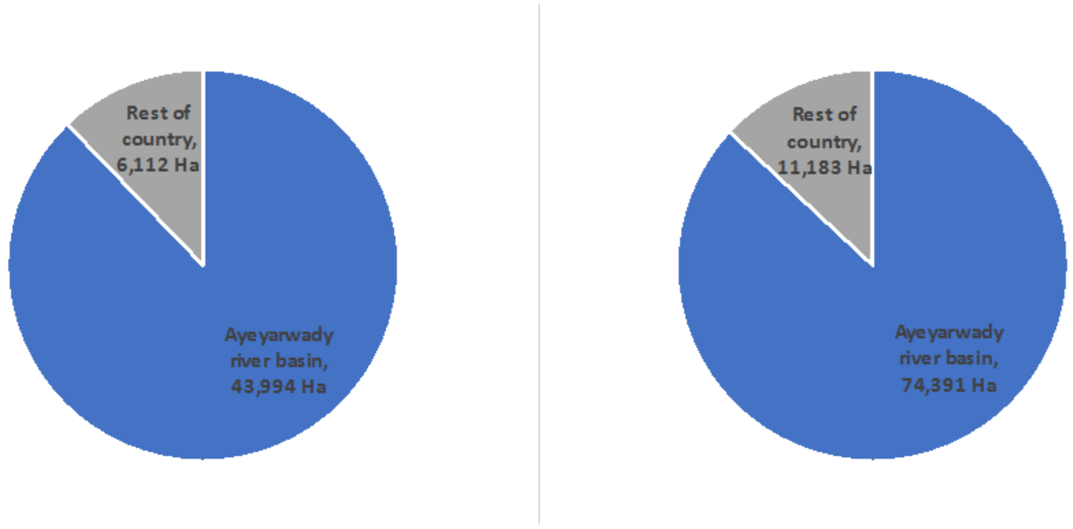


Figure 91 - Share of mining in 2015 by areas of high certainty (a) and likely to be mined (b)

(Eco-dev/ALARM 2016)

Figure 92 highlights the importance of Kachin state, Sagaing region, and Mandalay region in terms of mining activity, reinforcing the employment figures from the census. Taking high, medium, and low certainty mining activities into account, Sagaing region, Kachin state, and Mandalay region together account for approximately 84% of estimated ground disturbance due to mining activity in the country (Figure 92, b).

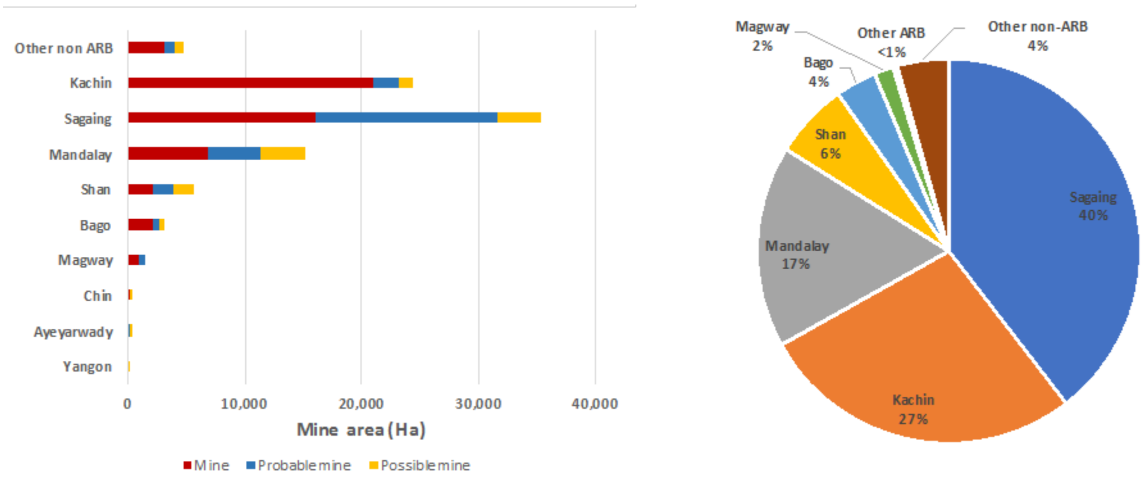


Figure 92 - Estimated mining area by Ayeyarwady Basin state/region in 2015, by certainty (a) and share of national total (high, medium, and low certainty; b)

(Eco-dev/ALARM 2016)

The analysis by Connette et al. (2016) also identified change in mining area through geospatial analysis identifying the change in bare ground within identified mining areas between 2002 and 2015. The findings for Ayeyarwady Basin states and regions are summarized in Figure 93. Nationally, for high certainty mining areas 62% of bare ground was newly disturbed between 2002 and 2015. Of this change the lion's share was accounted for by Kachin state and Sagaing region (Figure 93, right). Although these two areas saw a lower rate of mining expansion, with more rapid expansion taking place outside these traditional mining areas.

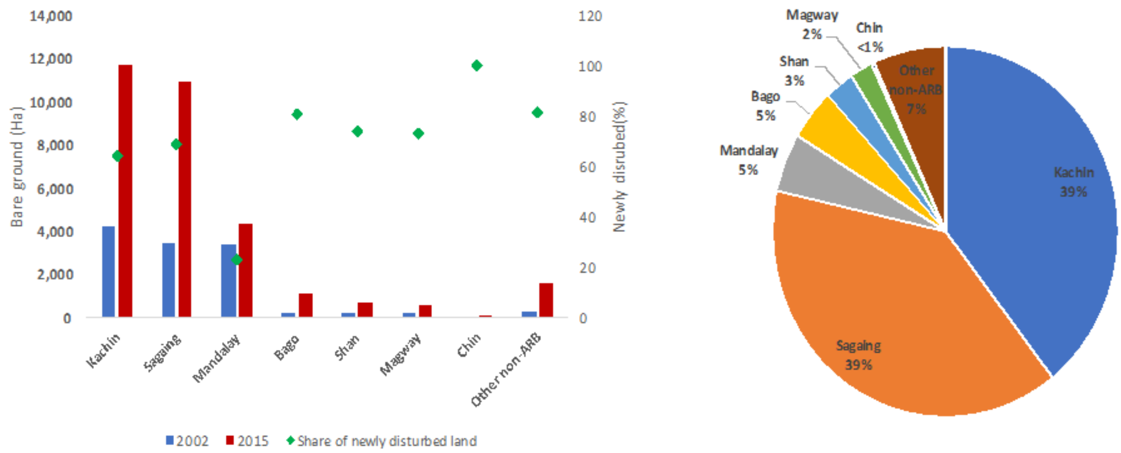


Figure 93 - Change in mining disturbance 2002 - 2015 and change in bare land and share newly disturbed (a) and share of national newly disturbed land (b) by state/region for high certainty mining areas

(Eco-dev/ALARM 2016)

Figure 94 shows the location of ground disturbance due to mining. From the distribution is clear that mining is concentrated in the Chindwin River Basin and the Middle Ayeyarwady HEZ. The Uyu River Basin in the Chindwin is particularly affected by mining (Figure 95). To the north of this basin are the jade mining areas, but the ground disturbance further south towards the confluence with the Chindwin is reportedly due to ASM gold mining activities. The large area of ground disturbance is probably explained by the reliance on hydraulic mining. The map also illustrates a pattern of mining along water courses visible along the Chindwin mainstream, the Mai Hka, and the Mu River, to name a few. In all likelihood, this ground disturbance is caused by alluvial gold ASM activities. The other centre of mining activity is Mandalay, where mining activity is located throughout the region and adjoining areas. The Mogok stone tracts are clearly visible to the northeast of Mandalay City. To the north along the mainstream Ayeyarwady, the Tagaung Taung nickel mine is visible as are the cluster of mines around Namtu-Bawdwin to the east of Mandalay along the Nantu River. A significant amount of mining activity is also visible around the headwaters of the Myitnge Basin, again probably small-scale alluvial gold mining. There is also a high concentration of mining activity closer to the city and in particular to the southern edge of the Middle Ayeyarwady HEZ. Again most of this activity is likely to be gold mining, but given the rich and varied mineral resources in the area, other types of mineral extraction are also likely to be important.

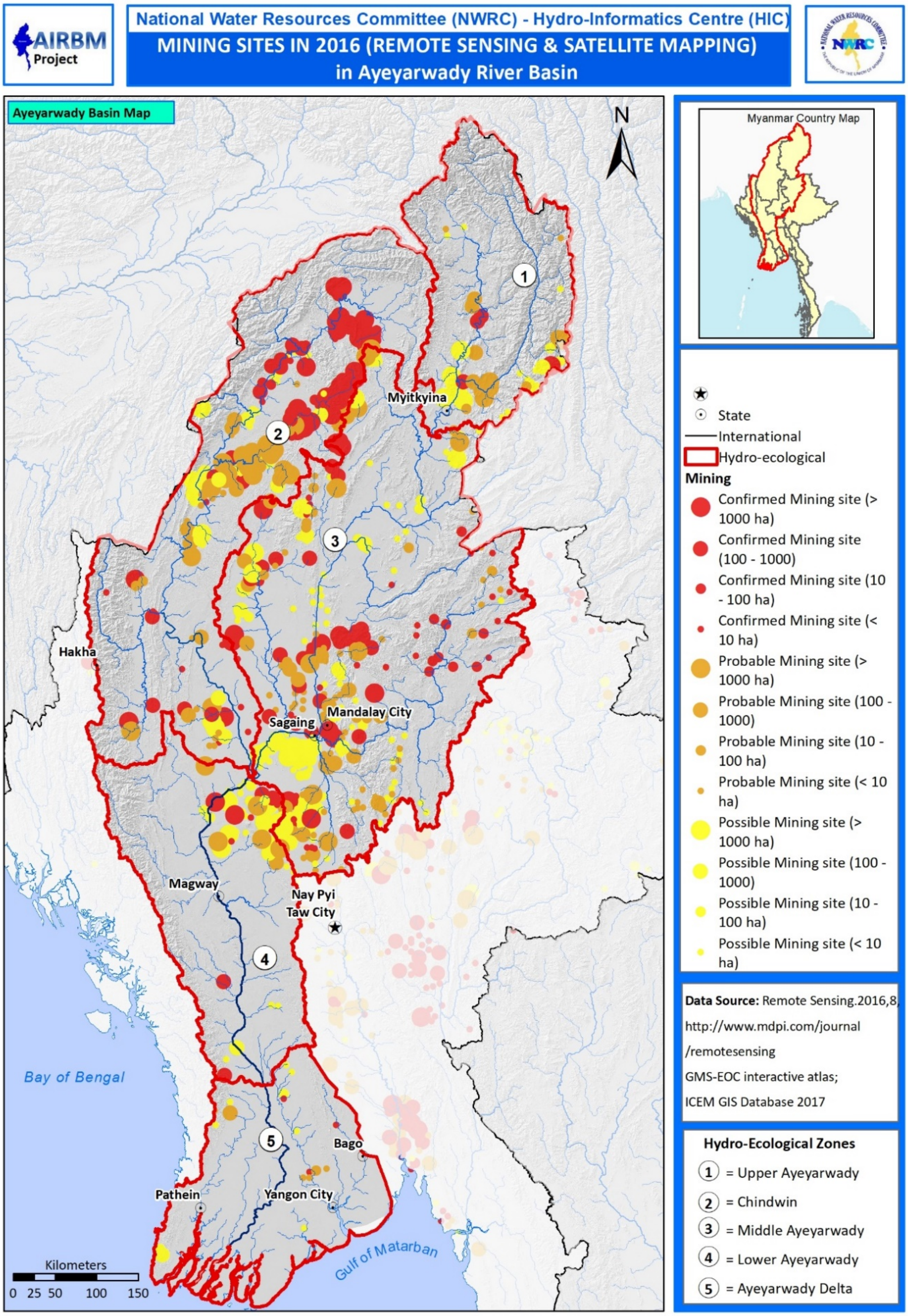


Figure 94 - Ground disturbance due to mining, 2015

(Eco-dev/ALARM 2016)

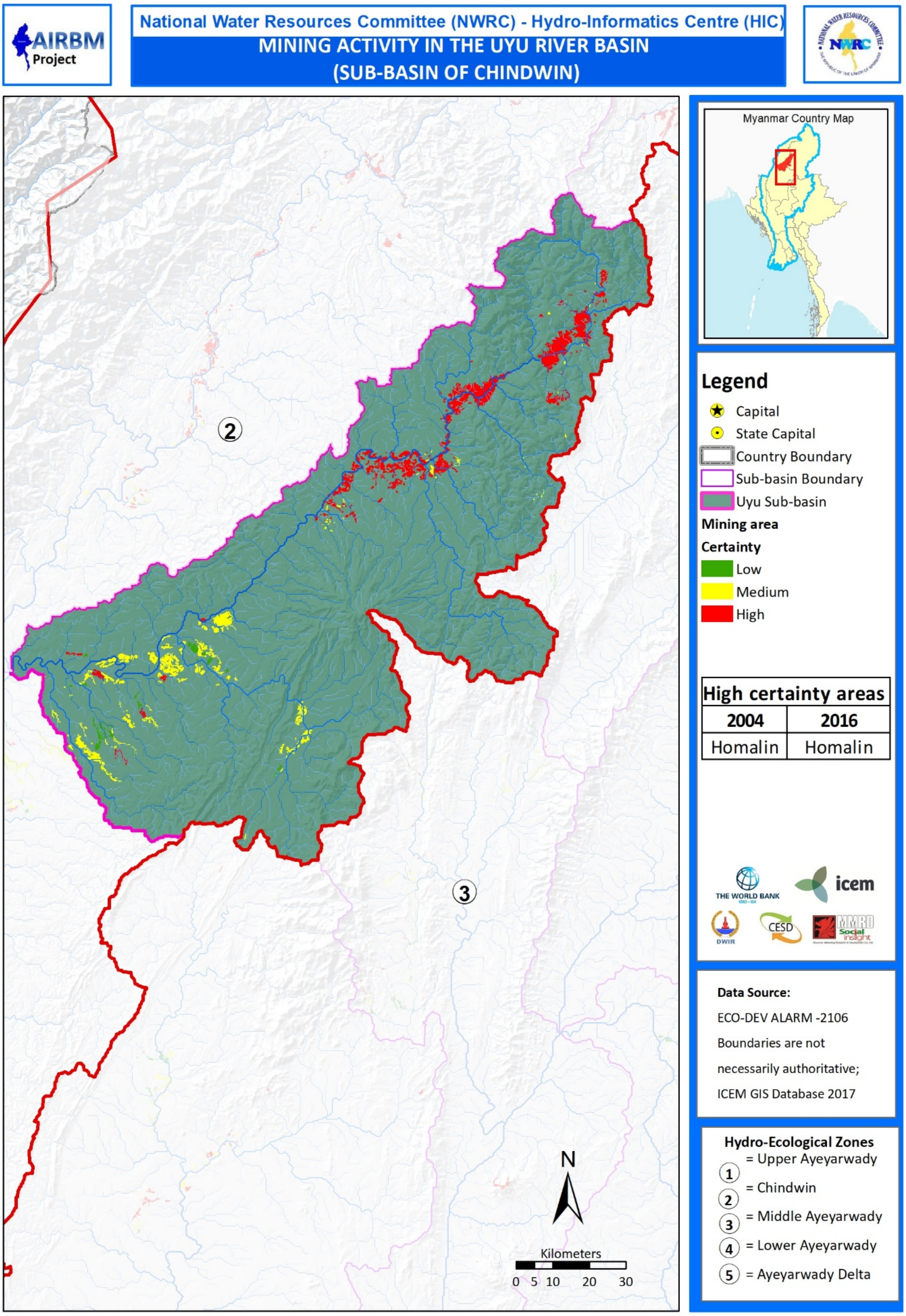


Figure 95 - Ground disturbance due to mining in the Uyu River Basin 2015 (high, medium, and low certainty)

7.4 Key Issues in the Mining Sector

7.4.1 *Sector development issues*

The legislation governing the mining sector has been improved in recent years. Under the previous government a long-term strategy for the development of extractive industries was described in two main documents: the National Sustainable Development Strategy 2009 and the Framework for Economic and Social Reforms 2012. Steps were also undertaken to strengthen transparency in the sector with Myanmar joining the EITI in 2014 and improvement of social and environmental safeguards through new legislation on Environmental Conservation (2012), Environmental impact Assessment (2015), and amendments to the Mines Law (1996) and rules (1996; MCRB, 2016). Early 2016 also saw the creation of the Mineral, Natural Resources and Environmental Conservation Committee, which replaced the Minerals and Natural Resources Management Committee of the out-going government. The Mineral, Natural Resources and Environmental Conservation Committee has a stated intention to reduce illegal mining activity and the environmental damage it causes, but has not provided details on how it intends to do this (MCRB, 2016).

Despite these recent regulatory improvements and growth in production in the mining sector in Myanmar and the Ayeyarwady Basin, the mineral geology remains underexplored, production is underdeveloped, and the sector remains largely unregulated, as the government is only able to effectively regulate the mining activities within which it is a JV partner (Irwin, 2016). Even in these cases there are indications that regulation is weak or ineffective (e.g., in the case of the Letpadaung mine).

Foreign investment in the sector is low relative to the potential, as a recent commentary points out in 2014 - 2015 only US$ 6.26 million of FDI was committed to the sector, compared to the US$ 3.22 billion which was invested in Myanmar's oil and gas industry (Carltons, 2015). Further development is constrained by a range of institutional, political, and infrastructural factors:

- Investors complain that the government has little understanding of the incentive structure facing investors in the exploration and mining. Essentially, exploration and mining are relatively high-risk investment activities, which as a consequence require significant returns on capital in excess of typically what is considered reasonable by government.
- This is coupled with unrealistic expectations of the value of mineral deposits, and current regulations (including production sharing contracts, high dead rents, and signature bonuses) that are unfavourable to exploration risk investment. Dead rents[23] are reportedly higher than in comparable jurisdictions (Carltons, 2015). Most concession agreements are based on production sharing contracts (PSC), as opposed to equity based or profit sharing agreements. Minerals exploration and development have high upfront costs, which are typically financed through debt. PSCs require production to be shared irrespective of profitability. Given high initial debt-service needs and low levels of initial profitability in the production phase, investors are therefore particularly sensitive to factors, such as PSCs, that may act to reduce profitability.[24]
- Complex procedures and overlapping central and sub-national government remits, and a poor business environment. Procedures for investment in the mining sector require foreign investors to enter into a JV agreement with one of the state-owned mining companies, with which they agree a PSC. There is duplication, redundancy, and an attendant uncertainty in the permitting of mining activities, which involves agencies from the national/Union, state, and region level, down to the village level, and across a number of sectors (mining, general administration, forestry, etc.). At the sub-national level the state mining SOEs can also be involved in enforcement and regulation of mining activities where they have a presence (MCRB, 2016).

[23] Rents payable per unit area of a mining concession, payable irrespective of mining activity. These differ depending on the stage of development, prospecting, exploration, development, or production and the type of mineral production engaged in.

[24] PSC can also incentivise inefficient and unsustainable mining practices; if profitability falls for any reason, it can mean that lower quality deposits are not effectively exploited, and mining companies focus only on the better quality and higher concentration ores (MCRB, 2016).

- Other risks include complex governance arrangements with multiple stakeholders, and an onerously complex tax and regulatory environment with few incentives for open disclosure and little enforcement or monitoring (Irwin, 2016; Reynolds 2014).

The perception of uncontrolled political risk in the sector arising from unresolved conflict, risk of complicity in human rights violations (in particular, related to the expropriation of land), and political uncertainty, also discourage foreign investment in the sector (MCRB, 2016). In addition to these barriers, investors also cite the lack of infrastructure including access to electricity for mining operations, poor roads, and communications infrastructure, and continuing conflict in some locations (MCRB, 2016; see Section 12). As such, the sector remains dominated by ASM[25] using antiquated techniques and technologies, with low productivity and extraction rates, very poor health and safety practices, and effectively no environmental controls.

7.4.2 ASM

An important aspect of mining in the Ayeyarwady Basin is the prevalence of ASM. As we have noted above this is common throughout the mining areas of the Ayeyarwady Basin and particularly concentrated in the jade mining areas around Holomin and Hpakant, the gemstone mining areas around Mogok and gold mining, both alluvial gold mining carried out throughout the Ayeyarwady Basin (particularly in the Upper and Middle Ayeyarwady, and Chindwin HEZs), and to a lesser extent in hard rock mining around Mandalay region, the western areas of Shan State and some areas of Sagaing region. ASM extraction of oil and coal are also important livelihood activities in some areas of Magway and Sagaing regions, as noted in the baseline report on energy.

There is little systematic information about artisanal mining in Myanmar. The census figures suggest it is a more common activity than is recorded in other official figures. Available estimates are anecdotal, and there has been no known survey work to establish the actual scale of ASM (save for the work on mining disturbance reported above). The task is made more difficult by the seasonal nature of the work; mining activities are often just one of many different activities individuals undertake.

However, recent work done in jade mining areas suggests that there are as many as 300,000 jade pickers working in the jade mining areas during dry season. There is some evidence that this has increased over recent years. Conditions in Hpakant and the surrounding areas are poor, worker camps lack amenities, drug addiction is rife and there have been a spate of deaths in recent years as jade pickers have been buried by landslides from unstable waste dumps. Nevertheless, young men, which comprise the majority of jade pickers, are attracted from all over the country, but particularly from the dry zone, and Chin and Rakhine states. Earnings at the mines are generally greater than earnings in these poor rural areas.

Conditions for gem pickers in the gem mining areas around Mogok may be improved, although mechanization of gem production and the exhaustion of placer deposits has probably limited work opportunities. Nevertheless, it is estimated that approximately 100,000 people are involved in ASM in the Mogok area. Similarly (refer to Chapter 5 - Energy), it is estimated that approximately 100,000 people are involved in artisanal oil extraction in Magway. Moreover, given the number of gold workings, the amount of people involved in gold mining on a full-time or on a seasonal basis across the basin must be significant. Generally speaking, and with the possible exception of the Mogok tracts, the number of people involved in ASM seems to be increasing.

As ASM is largely unregulated the rapid expansion of the sector has significant environmental and social implications (see Section 4.3 below). While the delineation of these impacts tend to focus on the negative aspects of ASM, it also represents a valuable income stream for many communities. Mining offers a means of ameliorating the chronic poverty which is still common in the rural areas of the Ayeyarwady Basin, where miners are often from. The implications of this are discussed below.

7.4.3 Social and environmental issues

[25] Small scale mining projects accounted for 1,165 of a total 1,299 licensed mining operations in late 2014 (MCRB, 2016).

Mining in the Ayeyarwady Basin is characterized by widespread social and environmental issues stemming from poor technology-use, skills and regulation, underinvestment, and control by vested interests. While the issues differ depending on the physical and social context of the mining operations and the type of mining taking place, the key environmental issues that are typical of mining operations in Myanmar include:

Erosion - Mining can directly or indirectly lead to increased erosion. Most mining in Myanmar is surface mining and involves extensive soil disturbance and removal of top soil and vegetation. Without any remedial action this can leave large areas of land vulnerable to erosion (Connette et al., 2016; KDNG, 2007). Hydraulic mining is particularly damaging. This type of mining mobilises large amounts of sediment potentially causing issues downstream. It also leaves large areas vulnerable to further erosion. Mining alluvial deposits on or near water courses can also exasperate erosion and cause riverbank instability (Global Witness 2016; MCRB, 2016; KDNG, 2007).

Deforestation and biodiversity loss - Mining is often associated with deforestation and loss of biodiversity. This is not only a consequence of the direct disturbance of land through mining activities but also through ancillary activities associated with mining. Timber is used for fuel, construction purposes within mines, and mining camps. The additional access to areas through the creation of mines may also open-up forested areas to logging. Similarly, NTFPs may be subject to unsustainable exploitation around mining camps and previously inaccessible areas opened-up to exploitation from the development of mining activities.

Agricultural land and productivity loss - As with forested areas, agricultural land can also be affected directly and indirectly from mining operations. Land can be lost directly to mining operations and can also be affected from the disposal of spoil, tailings, and pollution from mining sites. Changes in erosion, sedimentation, and hydrology caused by mining activities may also affect the productivity of agricultural land.

Water pollution and water quality - Water pollution is a key concern in mining activities. The type and extent of pollution will depend on the type of mining activities taking place. Key concerns include the widespread use of mercury in gold mining. A recent study showed that concentrations of mercury in mine-workers were 2.4 times that of the general population. High concentrations of mercury were also found among sediments in gold mining locations (Osawa and Hatsukawa, 2015). Cyanide is also widely used in the processing of gold and poses a threat to animal and human health if it contaminates the water supply. Acidification of water sources can take place either through the percolation of water through mined materials, through contaminated water drained from mines, or through the contamination of water bodies from tailings left as a result of ore processing (Smith, 2007). Other heavy metals (such as lead and cadmium) and naturally occurring radionuclides may also be mobilised and concentrated in the mining process and contaminate ground and surface water.

Other pollution - Dust and noise pollution from mining and quarrying activities can also cause significant localized environmental problems, impacting human and animal health.

In addition to these commonly cited environmental problems, a number of health and social issues associated with mining activities in Myanmar have been noted in the literature. The most important of these include the following:

Drug use - Drug abuse is widespread and well documented among mining areas. Miners reputedly take drugs to enable them to cope with the long hours of physically demanding work in the mines. Many miners are long-term users of heroin, with some estimates suggesting that up to 80% of jade miners in Hpakan are addicted to opiates (VOA, 2016). Widespread intravenous drug use and the sharing of needles among miners has also lead to high rates of HIV infection.[26]

Accidents - Mining is a dangerous occupation. Working conditions are hazardous, as people work in close proximity to large machinery and accidents involving collapses in mine workings and landslides occur.

Occupational health - Aside from accidents at work, miners are also prone to work-related diseases. Lung disease characterized by frequent lung infections is common, caused by the long-term inhalation of

[26] Médecins Sans Frontières treats nearly 2,000 HIV/AIDs patients in Hpakant, and an additional 8,000 at four other clinics in Kachin State. Myanmar Now, 20 June 2016, Jade miners' hopes of fortune often become tragedy of addiction. Available online at: http://www.myanmar-now.org/news/i/?id=07855944-5f27-4095-b358-d1bca7733090

Particulate Matter (PM) and water droplets during drilling without suitable respiratory equipment. Other health issues relate to exposure to poisonous substances such as mercury, cyanide, and contaminated wastewater.

Land issues - Expropriation of land for mining remains a critical issue at many mining locations. Farmers and other land owners are frequently evicted from land without adequate consultation, compensation, or resettlement. This issue is well documented at numerous locations.[27]

Booming sector effects - Expansion in mining in a location can cause localized price inflation as demand increases with an influx of mine workers, particularly for essential items such as food. This can cause hardship for households employed in other sectors.

7.4.4 Conclusion

From the point of view of river basin planning and development, the mining sector is important in a number of ways. First, it has significant economic importance. It is an important driver of economic productivity and growth, and is important in the generation of official and unofficial revenues for the national and sub-national government. Second, it generates a considerable amount of employment in the basin. In this regard ASM seems to be considerably more important than larger mining enterprises, although the distinction between ASM and mining enterprises is not always clear, as larger firms often rely on semi-independent artisanal miners for a considerable share of their product (e.g., in jade mining areas and in the Sagaing region coal mining areas). Third, at the same time, mining activity generates a host of social, public health, and occupational health problems. Fourth, mining activity has significant implications for sediment generation, pollution, and water quality. Land disturbance can create areas susceptible to erosion, and mining activities can actively mobilise sediments through dredging and hydraulic mining. Chemicals used in mining as well as tailings from mine working can cause pollution problems (e.g., acid mine tailings reported from copper processing at Monywa, increased mercury levels in sediments and miners, issues with cyanide use, etc.). Finally, mining activities can cause wholesale disruption to the surrounding environment, through overuse of NTFPs, timber, and other local resources.

[27] For example, conflict with villagers at Letpadaung copper mine, where 26 villages have been affected by the development remains ongoing (Zerrouk and Neef, 2013)

8 ENERGY

8.1 Introduction

The Ayeyarwady Basin hosts a number of significant potential energy resources, including HP, oil, gas, and coal reserves as well as good solar resources. Ensuring that demand for commercial energy is met in an affordable, secure, and sustainable manner in the basin, as elsewhere in the country, will be critical for Myanmar's development. At present, most of Myanmar's rural and urban household energy needs are met through the unsustainable use of fuelwood. Electrification has yet to reach the majority of the population in the Ayeyarwady Basin. Electricity demand outstrips effective supply capacity leading to frequent load shedding and power cuts. At the same time, Myanmar exports a significant portion of its energy in the form of natural gas and hydro-electricity.

The development of the energy sector in the Ayeyarwady Basin has significant implications for the sustainable management of resources within the river basin. Large energy development projects can have far reaching implications for the development of other sectors in the basin, as well as broader environmental and social outcomes. This is most obvious with HP development, but is also likely to be an issue with fossil fuel extraction and pipeline projects. At the same time, the extensive and unsustainable use of fuelwood for household energy needs and lack of electricity provision in remote areas represent important development impediments in the basin.

Drivers of energy development and consumption are geographically disparate and not bounded by catchment geography. This section, considering the energy sector in the Ayeyarwady Basin, focuses on the Ayeyarwady Basin energy sector explicitly within the context of an integrated nationwide energy sector. Thematically, the analysis of the energy sector is divided into four sections. The first two themes relate to the national energy balance and the contribution of activities within the Ayeyarwady Basin to it, namely: 1) Energy resources and supply - consideration of potential energy resources and energy production in the Ayeyarwady Basin and the significance of this in the national context; and 2) Energy consumption - energy consumption in the Ayeyarwady Basin and its national significance. The second two themes investigate issues more directly related to development activities within the basin: 3) Rural electrification - a short section that looks at the characteristics of rural energy use with a particular focus on the role of electrification; and 4) Power sector and HP development - which looks at current and pipeline HP development in the Ayeyarwady Basin and highlights the potential development and environmental implications for the Ayeyarwady Basin.

8.1.1 Overview of national energy production and supply

Figure 94 shows total primary energy production (TPEP), which is the total national energy production by energy carrier between 2000 and 2014. Over this period, energy production grew from approximately 11.5 million tonnes of oil equivalent (Mtoe) in 2000 - 2001 to 18.5 Mtoe in 2013 - 2014 (IES et al., 2015) by an annual average rate of approximately 3.45%. With the exception of coal, which saw a slight decline in production, all production from all energy carriers grew. Production of HP and natural gas grew most rapidly, the AAGR of energy production from HP ran at approximately 11.6% over the period and from natural gas at approximately 6.7%, meaning both increased their relative share in TPEP. Biomass represented the highest share of TPEP in 2000 - 2001 but by 2013 - 2014 this had been overtaken by production of natural gas. By 2013 - 2014 natural gas accounted for approximately 46% of TPEP and biomass approximately 43% (IES et al., 2015).

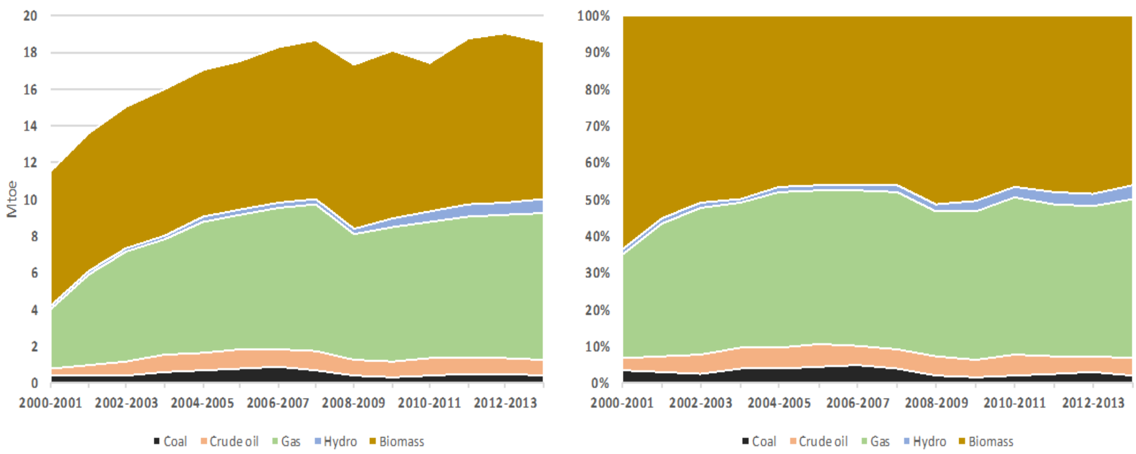


Figure 96 - Myanmar TPEP 2000 - 2001 to 2013 - 2014 Mtoe

(IES et al., 2015)

Total final energy supply (TFES) is a measure of the national energy supply, essentially total primary energy supply (TPES) net of stock changes and imports/exports. Despite imports of approximately 55% of oil products, Myanmar's significant exports of natural gas to China and Thailand result in a TFES significantly lower than TFEP. In 2013 - 2014, TFES was at approximately 14.1 Mtoe compared to a TFEP of approximately 18.5 Mtoe. TFES is a better reflection of domestic needs, with over 60% of energy supply being accounted for non-commercial biomass, 17% petroleum products and 14% natural gas (IES et al., 2015).

8.1.2 Energy exports

In recent years Myanmar has become a significant exporter of energy to China and Thailand. Off-shore natural gas fields (Shwe, Yadana, and Yetagun in the Andaman Sea) are the most important official source of export revenues for the country, accounting for US$ 3.71 billion in 2014 - 2015 (Nam et al., 2015). Most of this gas currently goes to Thailand (31.2 M m^3) and China (300 - 400 million cubic feet), with the remainder (300 - 350 million cubic feet) being used domestically (Oxford Business Group [OBG], 2017). To develop its gas and oil resources, Myanmar has relied upon production sharing contracts. As Myanmar shifts from the predominant pre-reform focus of generating foreign exchange earnings, to one of using domestic energy resources to support its own development, arrangements will have to allow for better serving domestic energy needs (OBG, 2017).

Electricity exports from HP plants in Myanmar have also been developed over the last decade. Currently, Myanmar has capacity to export 520 MW to China. This consists of 221 MW from the Dapein 1 project and 300 MW from Shweli 1 (i.e., half of the six 100 MW units). Dapein 1 makes 8% of the capacity available to the Myanmar grid at no cost, and provides a royalty of 15% of revenues. Shweli 1 provides 50% of its capacity to the grid at no cost and pays a royalty of 10% of revenues (Deloitte, 2015). This means that of the total installed HP capacity of approximately 3,150 MW, 2,630 MW serves domestic demand. More detail on the contents of these concessions or the Power Purchase Agreements for these projects have not been available (see Section 4 for greater discussion of power exports).

8.1.3 Ayeyarwady Basin energy resources in the national context

The Ayeyarwady Basin holds most the of the country's onshore energy resources. Table 74 gives an overview of current estimates of proven energy resources in Myanmar and the proportion represented by those located in the Ayeyarwady Basin.

Table 74 - Current national and Ayeyarwady Basin energy resources

(IES et al., 2015, Energy Planning Department unless otherwise stated)

Type	National		Ayeyarwady Basin share	
	Resource	Production	Resource	Production
Oil	50 - 459 million barrels (bbl)[1]	20,000 bbl day^{-1}	104 million bbl	8,000 bbl day^{-1}
Natural gas	286 - 470 billion m^3 [2]	20 billion $m^3 year^{-1}$	11 - 159 billion m^3	1.5 billion m^3 $year^{-1}$
Coal	466 Mt	790,434 t	214 Mt	N/A
Hydropower	108 GW	3,298 MW (large)[3] 34 MW (10 MW or less)	58.3 GW (50.8 GW Ayeyarwady, 7.6 GW Chindwin)	2,100 MW (large)[3]
Solar	51,973 terawatt hours per year (TWh y^{-1})[4]	-	N/A	-
Wind	4,000 MW, 365 TWh y^{-1} [4]	-	-	-
Biomass	21.7 million cubic metres per year (M m^3 y^{-1}) [4](fuelwood only)	38 - 50 M m^3 y^{-1}	-	19.8 M m^3 y^{-1} (household fuelwood only)
Geothermal	93 locations	N/A	N/A	N/A

[1] Low figures are derived from the United States Energy Information Administration and the higher figure from MoE, both cited in IES and MMIC (2015).
[2] EIA (2014) estimates 286 billion m^3, JICA 470 billion m^3 and ADB 334 billion m^3, figures from in IES and MMIC (2015).
[3] Figures from ICEM (2017).
[4] Figure from Zaw Min Niang (2017).

The Ayeyarwady Basin hosts almost all known onshore oil and gas fields, a significant proportion of national coal deposits and around half of the country's technical HP potential. The basin also holds significant renewable energy resources with high year-round levels of available sunlight in the CDZ making it particularly suitable for the development of solar, the coastal strip of the delta with some of the country's best wind potential and with extensive forest cover and agriculture providing sustainable biomass energy resources.

8.1.4 Energy production in the Ayeyarwady Basin

a) Oil and gas

Oil production has a long history in the Ayeyarwady Basin, with oil production documented from the eighteenth century in the area around Yenangyaung using hand dug wells (Cox, 1971). The Ayeyarwady Basin also hosts significant natural gas reserves with production dating from the 1970s, although development of the oil and gas sector has been stymied due to Myanmar's economic isolation and a lack of investment (UKTI, 2015). No new oil reserves have been discovered in the last 20 years, and production has fallen as a result of the depletion of existing reserves. Annual oil production fell from approximately 12 million bbl in 1984 to approximately 7.3 million bbl in 2013 - 2014. Currently, Myanmar meets approximately 45% of its oil needs and all of its gas needs through domestic production. Gas production has decline significantly from approximately 1,500 M m^3 y^{-1} in 2000 - 2001 to approximately 618 M m^3 y^{-1} in 2013 - 2014 (IES et al., 2015).

Table 75 reports oil and gas reserves and production in the Ayeyarwady Basin. The final column reports the reserve-to-production ratio in years, which shows how long at current levels of resource extraction the resource could be expected to last. It should be noted, as with the figures reported in Table 74, these estimates vary between sources, with significant order of magnitude differences in estimates from the Ministry of Energy and the United States Energy Information Administration (IES et al., 2015). Known onshore oil reserves account for approximately 23% of proven oil reserves and approximately 40% of annual production, all onshore reserves are situated within the Ayeyarwady Basin. Onshore gas reserves, again all located within the Ayeyarwady Basin, account for approximately 20% of national proven reserves.

Table 75 - Oil and gas reserves and production in the Ayeyarwady Basin

(MoE figures from IES et al., 2015)

Resource	Proven	Probable	Production	Reserve-to-production ratio, in years [probable]
Oil	104 million bbl	355 million bbl	8,000 bbl day^{-1}	36 [157]
Gas	158.6 billion m^3	15 billion m^3	617.82 M m^3 y^{-1}	257 [282]

Figure 97 shows the location of sedimentary basins in the Ayeyarwady Basin, the exploration status, and the location of oil and gas infrastructure in the Ayeyarwady Basin. All onshore gas and oil extraction is currently confined to the Ayeyarwady Basin and most of the proven oil and gas reserves are also situated within the basin. While large areas of the sedimentary basins within the Ayeyarwady Basin have been explored, there remain significant areas to the north of the basin yet to be explored (ADB, 2011). It should be noted that these figures do not include the extensive informal oil extraction that takes place within the Ayeyarwady Basin (see below).

The Ayeyarwady Basin is also home to most of Myanmar's onshore gas and oil infrastructure. Myanmar's three oil refineries at Minhla, Thanlyin, and Chauk are all within the basin. Similarly, most of the 4,500 km of onshore gas pipelines in the country are in the Ayeyarwady Basin. The trans-Myanmar gas and oil pipeline also cuts across the Ayeyarwady Basin. This pipeline takes gas from the Shwe field in the Bay of Bengal and oil from the Arabian Gulf trans-shipped near Kyaukphyu to Kunming in the PRC 770 km away.[28] The reported investment cost was approximately US$ 2.5 billion. The gas pipeline was commissioned in 2013 and the oil pipeline in 2017. Myanmar is also contracted to receive up to 50,00 bbl day^{-1} through the oil pipeline.

Box 4 - Oil and gas facilities pose danger to public

(Htun Khaing 2017)

In 2010 in Aiggyi Village, in Magway Region's Pakokku Township an explosion caused by an oil leak from a poorly maintained government pipeline linking the Thargyi Taung and Ayadaw fields. A large quantity of oil had leaked out covering an area of ground. Reportedly, hundreds of people had gathered at the site to collect the oil which could be resold. The oil became ignited and there was an explosion. Fourteen people were killed and a further 121 injured (although other reports suggested 400 were killed). Reports suggest that prior to the incident, the pipeline was poorly maintained. Government officials acknowledge that some pipelines developed in the 1990s are currently in a poor state of repair. A similar incident took place in 2012 when a train transporting oil exploded near a village in Sagaing Region's Kanbalu Township, injuring approximately 90 people, and killing 25.

MOGE has tried to publicize the safety consequences of living near pipelines and with collecting spilled oil, but people still burn rubbish near pipelines or construct houses in their location. For example, in Yangon's outer western Shwepyithar Township it is estimated that approximately 1,000 people have constructed dwellings on gas pipelines supplying the area's many factories.

[28] Avoiding the straits of Malacca, this effectively diversifies China's oil supply routes.

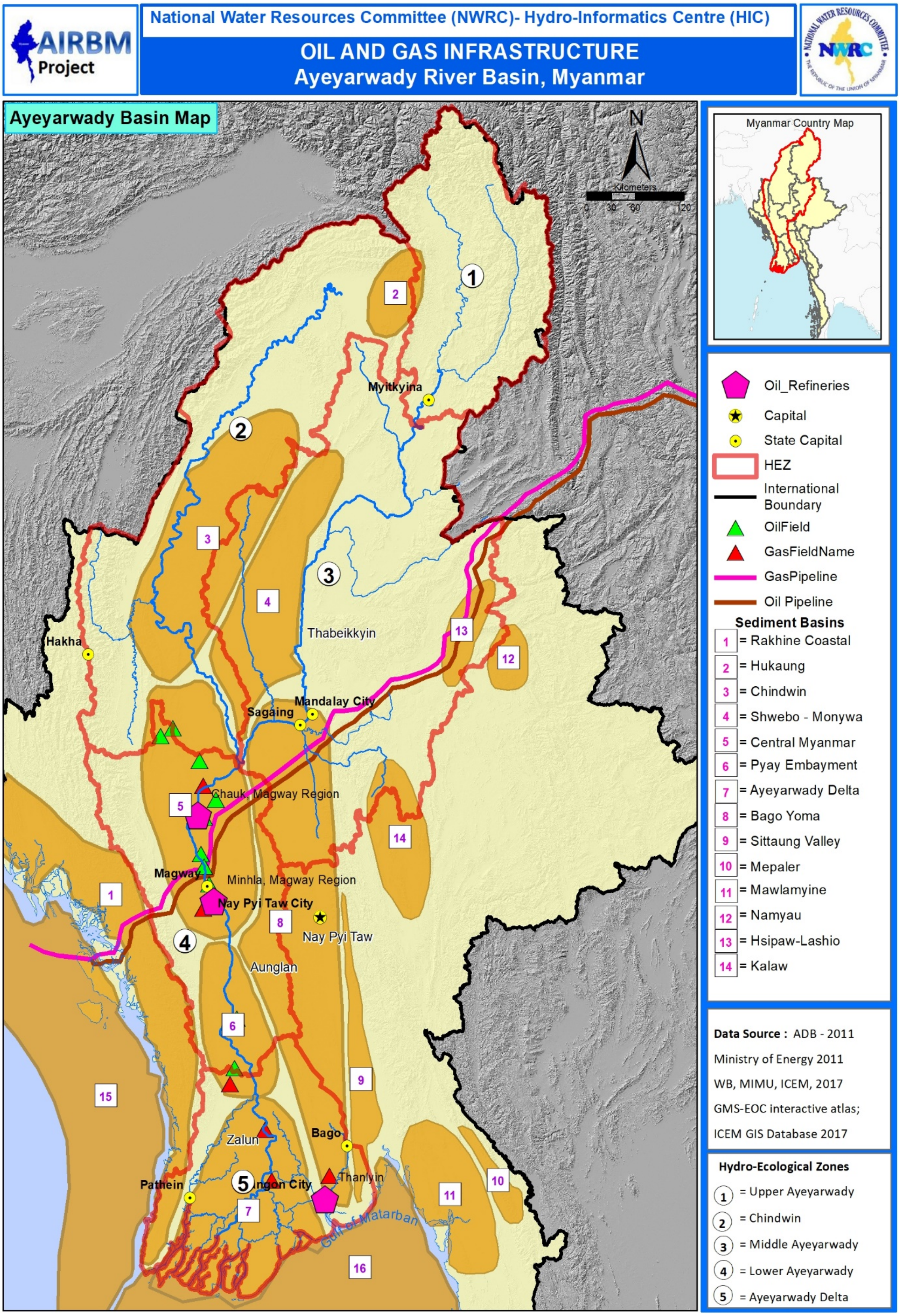


Figure 97 - Oil and gas exploration blocks in the Ayeyarwady Basin (a) and location of sedimentary basins, oil and gas fields in Myanmar

b) Artisanal oil extraction and refining in the Ayeyarwady Basin

Oil extraction is concentrated in Magway Region, which is home to seven oil fields. The state owned and operated Mann oilfield north of Minbu Town is home to approximately 669 oil wells operated by MOGE. South of Minbu lies Minhla, also on the Ayeyarwady. Here there are extensive small-scale and artisanal oil extraction activities (NRGI, 2015). Htankhine and Da Htut Pin oil fields are operated by the domestic private sector, after MOGE returned control of the land to landowners in 2013. Some estimates suggest that in 2013 there were as many as 40,000 small wells in the area (Sanay Lin, 2013). According to reports, much of the exploration and extraction conducted in the area is illegal.

As a consequence of these developments in the area it is estimated that since 2006, 100,000 people have been drawn to Htankhine and since 2013, 400,000 to Da Htut Pin (Aung Htay Hlaing, 2014). These figures include both those involved in extracting oil, as well as small traders and businesses drawn by the population expansion in the region. Given the current low oil price it is not clear how much small-scale oil extraction is taking place at present. Recent reports suggest oil production in Minhla has slumped from 2,000 bbl day^{-1} in 2014 to less than half of this in 2016 (Nay Aung, 2016). While this represents a rather modest level of production, it should be noted that this is approximately 25% of production in the Ayeyarwady Basin. It is unclear if official figures include small-scale and artisanal oil production, as much of it is in the informal sector.

In addition to artisanal and small-scale oil extraction, in Sagaing Region there are a significant number of small-scale refineries refining oil extracted by small-scale operators. These refineries use relatively primitive methods and produce low octane, low-quality products. Currently, there are approximately 100 refineries working in Sagaing region, and this reportedly represents a significant reduction due to decreases in oil prices and margins for refineries. These operations are effectively unregulated and pose a significant potential environmental and occupational health hazard. Moreover, in terms of energy use, they use large and unsustainable amounts of fuelwood to provide energy in the process of cracking.

c) Coal

Myanmar has significant coal deposits but these only play a relatively minor role in energy supply, at approximately 1.9% of TPEP in 2013 - 2014 (IES et al., 2015). Recent reports suggest that the low share of coal in the energy mix is a consequence of the low quality of reserves (with a large proportion of lignite and sub-bituminous coals) and the continuing use of outdated technologies in the sector. Recent figures suggest that there are over 500 occurrences of coal in Myanmar, and estimated reserves of 466 Mt (IES et al., 2015). Deposits are spread throughout the country with significant lignite deposits in Eastern Shan State as well as deposits in the Ayeyarwady Basin.

Figure 98 and Figure 99 show the geographical distribution of coal resources in the Ayeyarwady Basin. Figure 96 shows the location of coal basins in the Ayeyarwady Basin and occurrences of coal. Within the Ayeyarwady Basin, the Chindwin and Minbu-Salin basins account for most of the significant coal occurrences; Figure 97 shows the locations of coal reserves with a known resource greater than 10 Mt, and serves to emphasize this finding. The largest deposit of sub-bituminous coal is found at Kalewa in the Chindwin River Basin, with total estimated deposits of approximately 87 Mt. The deposits at Kalewa and Tamu in the Chindwin are also notable for holding coal of qualities that are suitable for combustion at power plants (IES et al., 2015).

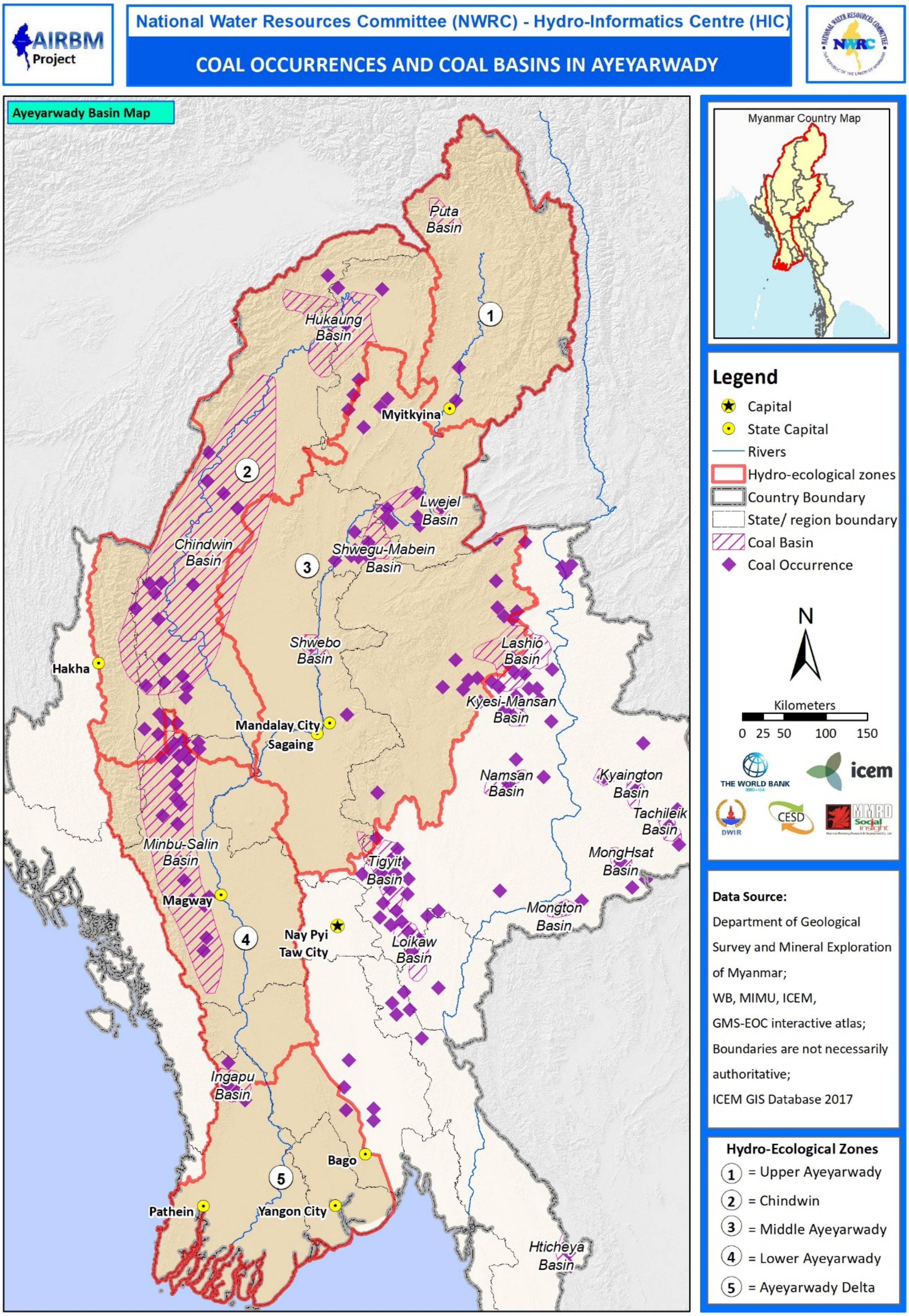


Figure 98 - Coal occurrences and coal basins in the Ayeyarwady Basin *(DoM)*

As with oil extraction, artisanal and small-scale coal mining is common. Recent reports have highlighted widespread artisanal coal mining in Magway and Sagaing regions. Townships where artisanal and small-scale mining (ASM) is common include Kalay, Tamu, and Mawlaik in Sagaing Region, and Ngape Township in Magway Region. ASM coal mining activity has expanded in recent years in part to the reduction in economic opportunities in small scale oil extraction in the region, due to the low oil price. Miners typically work for landowners, and sell the coal to larger companies. Although only three such companies have been granted coal extraction concessions, approximately 30 are actually operating using only exploration licenses. These mines generally extract lignite. These mining activities are effectively unregulated and mining practices are often dangerous with frequent accidents. Mine workings present a hazard for residents and livestock, and as there is no environmental remediation activity, disused mines are dangerous and hamper the return of land to agricultural uses (Kinh Su Wai, 2015).

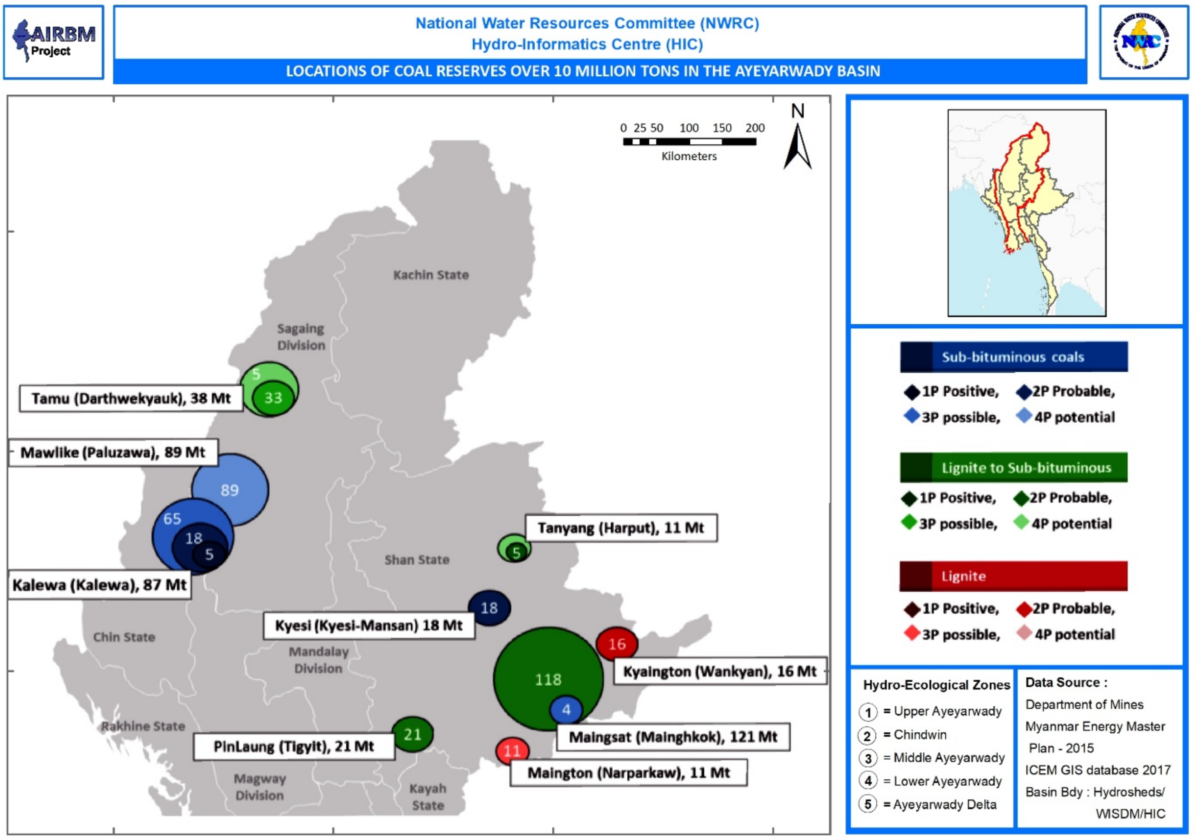


Figure 99 - Locations of coal reserves over 10 Mt in the Ayeyarwady Basin (DoM)

d) Hydropower

As noted in Table 74 above, technical HP potential in Myanmar is estimated to be approximately 108 GW. Approximately 58.3 GW of this is in the Ayeyarwady Basin, of which approximately 7.6 GW is in the Chindwin River Basin. Of this, 300 potential projects have been identified with a combined potential of approximately 46 GW (WWF, 2016). At present 14 large HP plants[29] are in operation in the Ayeyarwady Basin, with a total installed capacity of approximately 2.1 GW, approximately 64% of installed HP capacity in the country (ICEM, 2017). In addition, there are also approximately 33 MW of installed capacity of small HP plants in the Ayeyarwady Basin. Figure 98 shows the location of HP plants currently in operation in the Ayeyarwady Basin.

[29] Large HP plants are defined as those of 10 MW capacity or above.

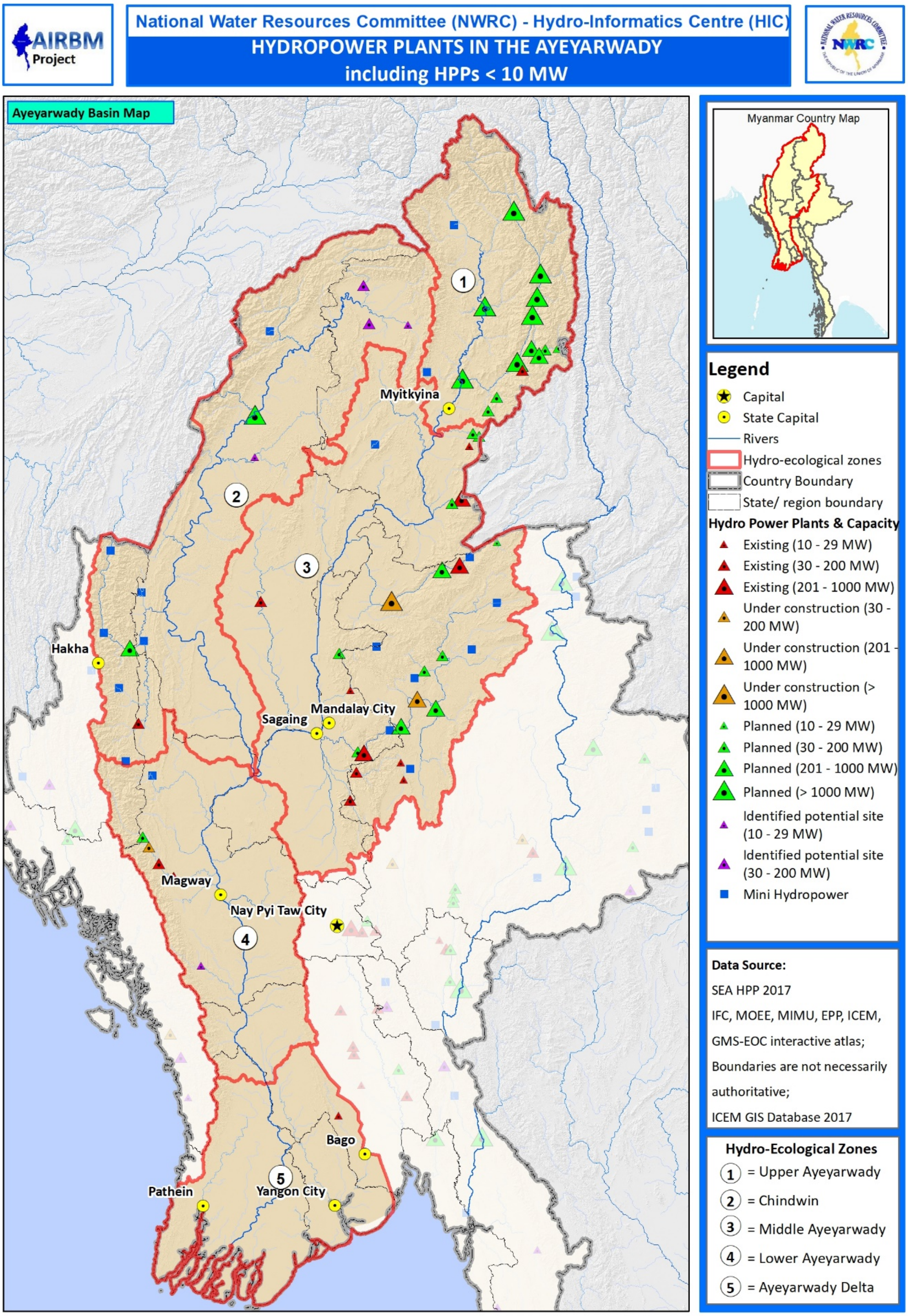


Figure 100 - Hydropower plants in the Ayeyarwady Basin, existing, under construction, and planned as of June 2017

(ICEM, 2017)

Table 76 gives the name and basic characteristics of the 14 large plants currently in operation in the Ayeyarwady Basin. Most of the projects are for multiple use combining power generation and storage for irrigation. Most of the small HP plants in the Ayeyarwady Basin are also for multiple use.

Table 76 - Hydropower projects in the Ayeyarwady Basin

(ICEM, 2017)

Plant name	Installed capacity (MW)	Commercial operations date
Chipwi Nge	99	2013
Dapein 1	240	2011
Kinda	56	1990
Kyee Ohn Kyee Wa	74	2012
Mali	11	2006
Mone Chaung	75	2004
Myittha	40	2017
Myogyi	30	2015
Sedawgyi	25	1989
Shweli 1	600	2009
Thapanzeik	30	2002
Yeywa	790	2010
Zawgyi I	18	1995
Zawgyi II	12	2011

Table 101 shows the development of HP capacity in the basin. Relatively little HP potential was developed during the 1990s and by 2000 the installed capacity in the Ayeyarwady Basin was only approximately 215 MW. After 2008 the installed capacity increased rapidly with the commissioning of large projects at Shweli 1 (600 MW), Yeywa (790 MW), and Dapein 1 (240 MW) between 2009 and 2011.

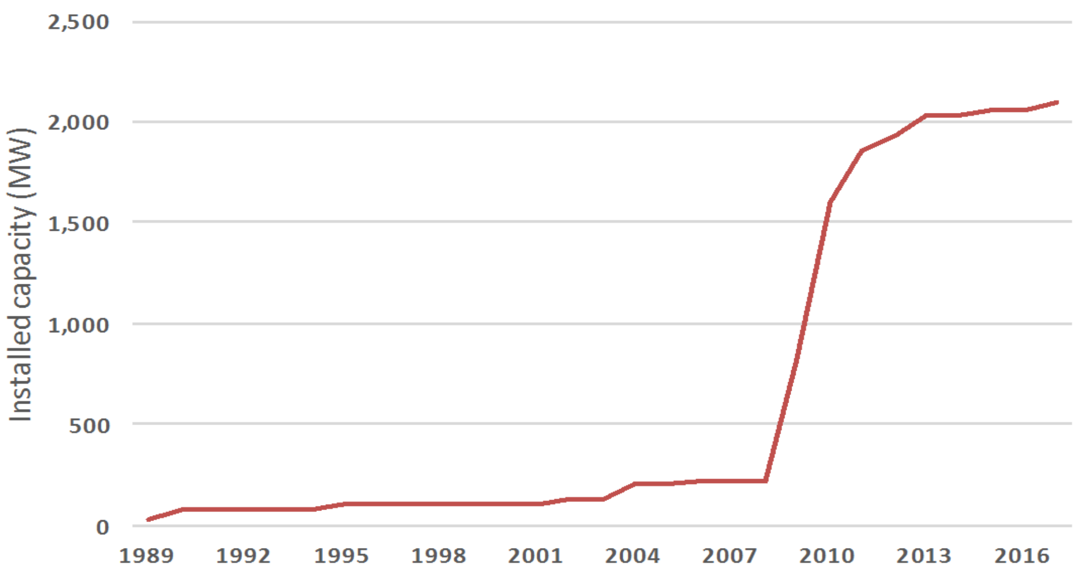


Figure 101 - Installed large HP capacity in the Ayeyarwady Basin 1989 – 2017

(ICEM, 2017)

Currently installed capacity is less than 4% of the technical potential in the Ayeyarwady Basin. The current pipeline of projects contains approximately 18.5 GW of HP (excluding the 6 GW Myitsone project), of which 1,372 MW is under construction (Buywa, Upper Yeywa, and Shweli 3). Hydropower development is discussed in greater detail in Section 4, on HP and the power sector.

a) Biomass and biogas

Biomass remains the most important source of energy in Myanmar and the Ayeyarwady Basin, accounting for over 60% of TFES in 2013 - 2014 (IES et al., 2015). Sources of biomass include fuelwood (also used for charcoal production), wood waste from timber processing, agricultural residues (bagasse, rice husks, etc.) and animal waste. Estimates of the availability of these resources are reported in Table 77, which gives the estimated national resource and share of the Ayeyarwady Basin in these figures. As the recent energy masterplan notes, fuelwood accounts for approximately 90% of biomass energy production.[30]

Reliable production figures do not exist and most estimates are derived from estimates of consumptive use at household level (see Section 3 on energy consumption). Fuelwood and charcoal is used by most households for cooking and heating. The extent of utilization of other potential biomass material is not clear. Animal waste, rice husks, and wood waste are suitable for biogas production and can be used to generate renewable electricity. Biogas digesters are increasingly common in the country with 158 digesters serving community energy needs and 29 household units (Zaw Ming Naing, 2017). Gasifiers producing syngas for electricity generation using rice husks as a feedstock are also common in rice producing areas such the delta, which hosted approximately 927 gasifiers in 2014 (MRI and Fujita Corporation, 2015).

Table 77 - Biomass resources in the Ayeyarwady Basin and nationally

(Zaw Ming Naing, 2017)

Biomass	Estimated national resource (Mt yr^{-1})	Estimated Ayeyarwady Basin resource (Mt yr^{-1})
Rice husk	4.4[31]	2.5
Lumber waste	1.5	-
Bagasse	2.1	-
Livestock waste	34.4	30[1]
Fuelwood	9.0 - 12.1[2]	-

[1]Based upon number of LSUs in the Ayeyarwady Basin in 2010 (approximately 82.5 million) multiplied by 10 kg per animal/LSU per year.

[2]Annual sustainable fuelwood use is estimated to be 21.7 M m^3. Conversion to tonnes depends upon the density of wood, but is generally deemed to fall between 0.42 - 0.56 tonnes per cubic metre.

b) Renewables

Aside from biomass there is significant renewables potential in the Ayeyarwady Basin, most as yet unutilized. Myanmar has significant solar potential, as noted above estimates suggest that the country as a whole has the potential to produce approximately 52 TWh y^{-1} (Zaw Min Niang, 2017).

Figure 102 below shows the potential for solar PV in the Ayeyarwady Basin. The best solar resources are in and around the CDZ (Middle Ayeyarwady HEZ), although with the exception in the far north of Kachin State and Sagaing Region, most of the Ayeyarwady Basin has good solar resources. Currently, there are two grid-connected utility scale solar photovoltaic (PV) plants in the development pipeline, the Nabuiang and Wundwin 300 MW project in Mandalay Region, and the 220 MW Minbu solar power plant in Magwe (Zaw Min Niang, 2017). Household solar PV systems are also relatively common in rural areas, with over 365,000 households in 2016 using solar systems (Zaw Min Niang, 2017).

[30] Other estimates based on the National Forestry Master Plan suggest that fuelwood supply in 2002 approximated 31.55 M m^3, of which 3.4% was sourced from plantations, 25% from non-forest land, 0.2 % from community forests, and 71.4% from natural forests. It is unclear whether this is net of lumber waste, or indeed the extent to which this represents a sustainable level of fuelwood production.

[31] Approximately 20% of the weight of paddy is comprised of rice husks.

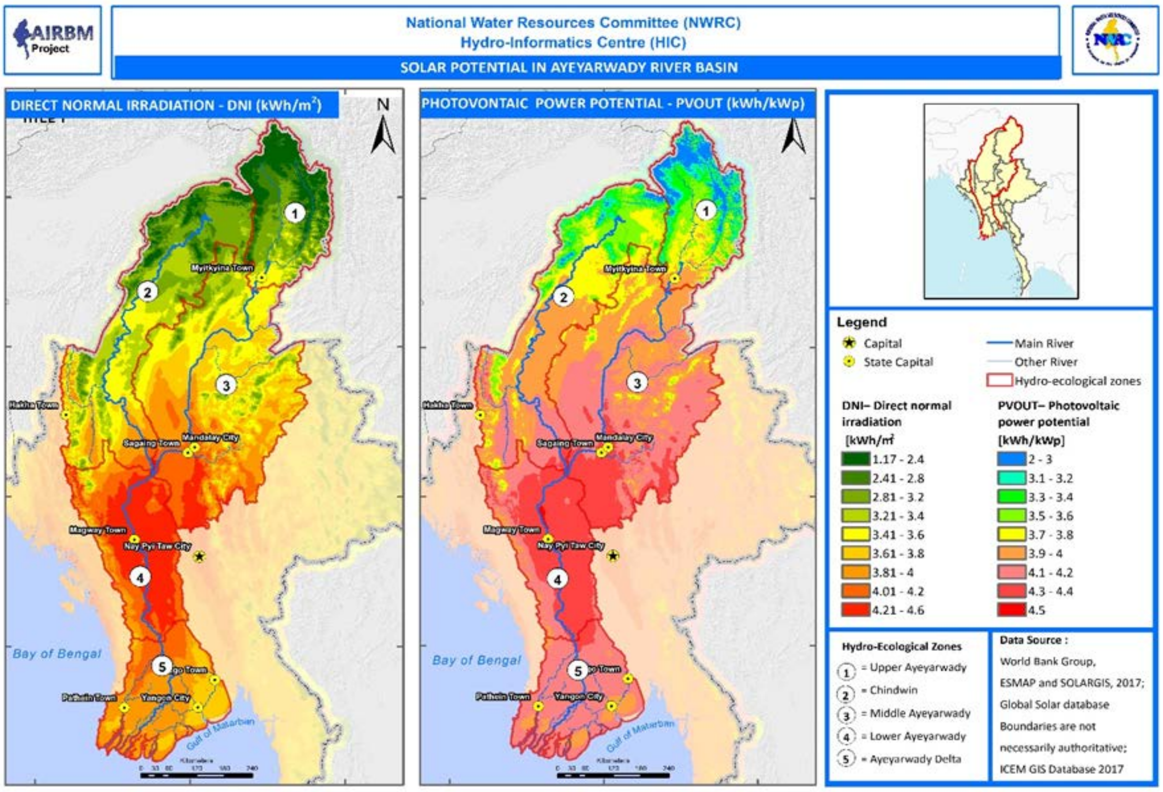


Figure 102 - Solar potential in terms of direct normal irradiation (a) and potential solar PV output (b)

(ESMAP and SOLARGIS, 2017)

Wind resources are more limited, with an estimated 4,000 MW of potential nationally. Areas in the Ayeyarwady Basin with the best feasible wind potential, based on an assessment of wind power density, include coastal areas of the Ayeyarwady Delta and Yangon and the area of the CDZ where the regions of Sagaing region, Magway region, and Mandalay region meet (Zheng, 2016).

Figure 103 illustrates wind potential in the Ayeyarwady Basin using average annual wind speed.[32] Indeed, most of the feasible wind potential in the country (with the exceptions of some coastal areas in Rakhine and Mon states) are within the Ayeyarwady Basin. There are plans for some onshore wind projects in the Ayeyarwady and Yangon regions, to be developed by the China Three Gorges Company, although the project also covers Rakhine and Chin states and it is unclear what proportion of the slated 1.1 GW capacity will be developed in the Ayeyarwady Basin (Zaw Min Niang, 2017).

[32] Note high wind speed in mountainous areas does not indicate suitability for wind power development, as these are too far from significant load centres (such as Yangon and Mandalay) or the terrain is unsuitable for the development of turbines.

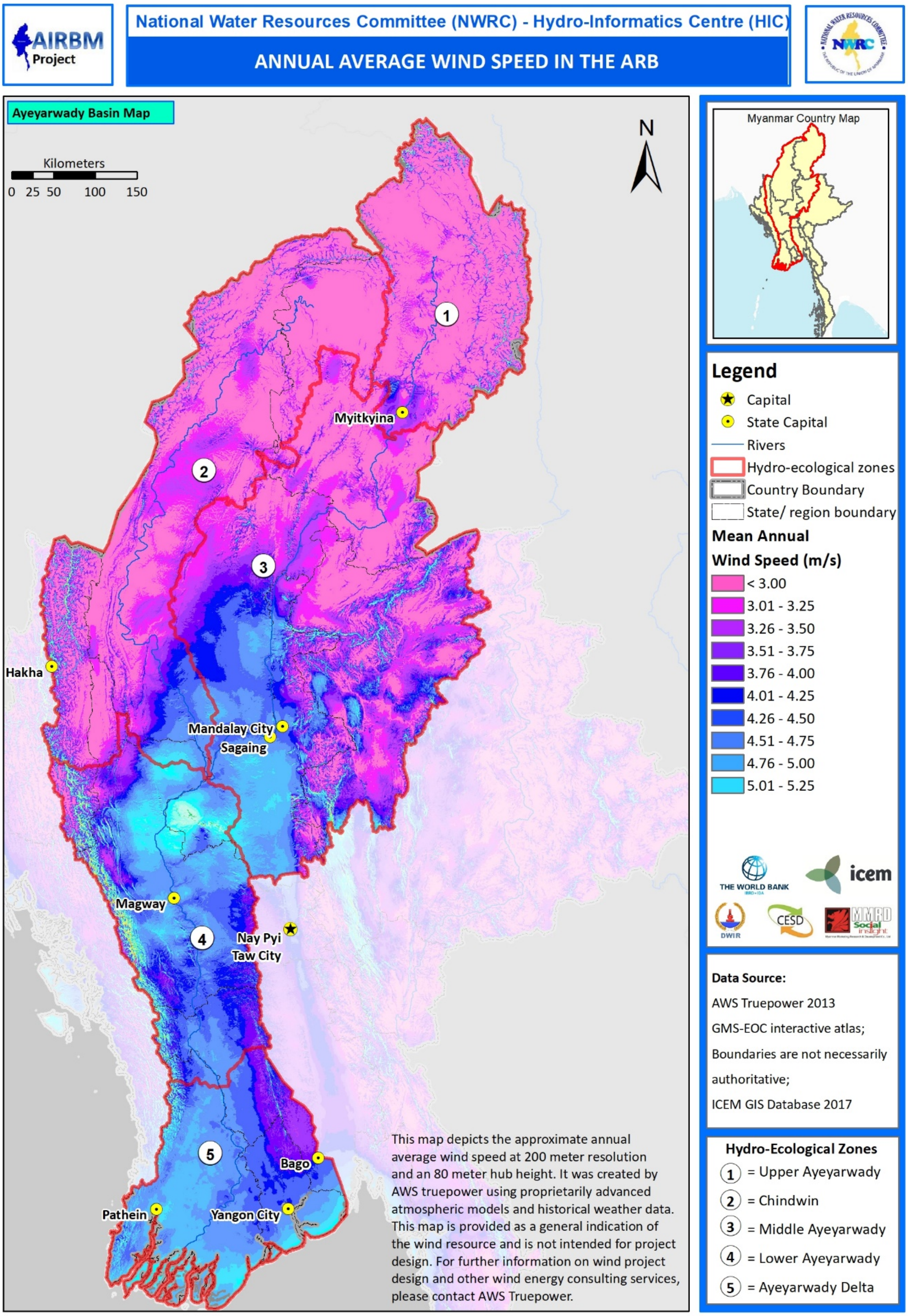


Figure 103 - Annual average wind speed in the Ayeyarwady Basin

(AWS Truepower, 2013)

There is also considerable geothermal potential with 93 hot springs recorded across the country. While most of these are in Mon State outside the Ayeyarwady Basin, there are springs in Kachin state and Central Myanmar. Currently, 43 sites are being tested by MOGE and Myanmar Electric Power Enterprise in cooperation with foreign investors; it is unclear which of these sites is within the Ayeyarwady Basin (WWF, 2016).

8.1.5 Key issues for energy production in the Ayeyarwady Basin

a) Development of the energy sector

Access to modern energy supplies in the Ayeyarwady Basin is limited (see Section 8.2 on energy consumption below). Household energy needs and the needs of productive sectors have not been adequately served by the government provision of energy services. Limited access to modern energy sources stands in a marked contrast to Myanmar's domestic energy resources (both fossil fuels and renewables), which are substantial. The key barriers facing development of production in the energy sector have been political and institutional. In part, the lack of energy production development is explained by the legacy of decades of international isolation and the lack of technology and financial wherewithal to fully utilize energy resources. In part, the lack of investment also reflects the uncertain institutional and policy climate. Investment in the sector is complicated by overlapping institutional mandates, unclear policy direction, and inadequate legislation. While foreign investment in the sector is slowly increasing, the historical lack of investment poses a serious constraint to the sector.

b) Environmental issues relating to the sector

The more pressing issues regarding river basin planning relate to the environmental impact of energy production in the Ayeyarwady Basin. Fossil fuel extraction can lead to issues with water pollution, while oil extraction and refining locations can lead to issues around land pollution. Oil and gas pipelines run the risk of leakage, which has the potential to cause serious pollution as well as pose a threat to the safety of people in pipeline areas (see Box 4 above).

We have pointed out that unregulated ASM-type extraction and refining of oil poses particular localized environmental hazards, including water and soil contamination with oil products and health hazards to those working in this sector without adequate protective equipment and sufficient health and safety regulation. Similarly, ASN coal mining potentially presents a range of hazards including water pollution, and particularly occupational health and safety consequences.

Coal mining is associated with a number of important environmental risks, particularly relating to water pollution. Tailings or coal storage areas can pose environmental and safety hazards if not managed properly. Acidification, particularly for coal with high pytite content, is a potentially significant environmental risk. Acidification can also act to release other elements (e.g., Al, Cu, Cb, and Pb) present in minerals in the coal drainage water from refuse piles. Such excavated and residual minerals can be very acidic, particularly if the rocks contain pyrite that undergoes oxidation when exposed to the air. Trace elements can also be leached from the soil and bed-rock as acidic tailings percolate through rocks. Water drained from coal mines can similarly be a source of pollution. This is likely to be a concern in the Kalewa area on the Chindwin River.

More generally, the development of energy production infrastructure can have wide-ranging environmental impacts, particularly including loss of natural habitats and forests. Water and land use in the production of energy is important across practically all forms of energy production, although renewables and HP tend to make more intensive use of land relative to fossil fuels. Hydropower in particular has potentially a range of impacts related to ecosystems and hydrology that are discussed in Section 8.4.

8.2 Energy Consumption

8.2.1 National context

Between 2000 - 2001 and 2013 - 2014, annual energy consumption grewslowly, from approximately 10,000 Ktoe at the beginning of the period to 13,000 Ktoe in 2013 - 2014. Despite relatively rapid GDP growth over the period, energy consumption per capita increased slowly between 1990 and 2014 at an average rate of approximately 1.5% (Figure 102). However, since 2010 energy use per capita has increased at a much higher annual rate of approximately 7.4%. At the same time, energy intensity of the economy declined by approximately 79% between 1990 and 2010. Since 2010, reflecting the overall increases in energy consumption, improvements in the efficiency of energy use as indicated by energy intensity have declined.

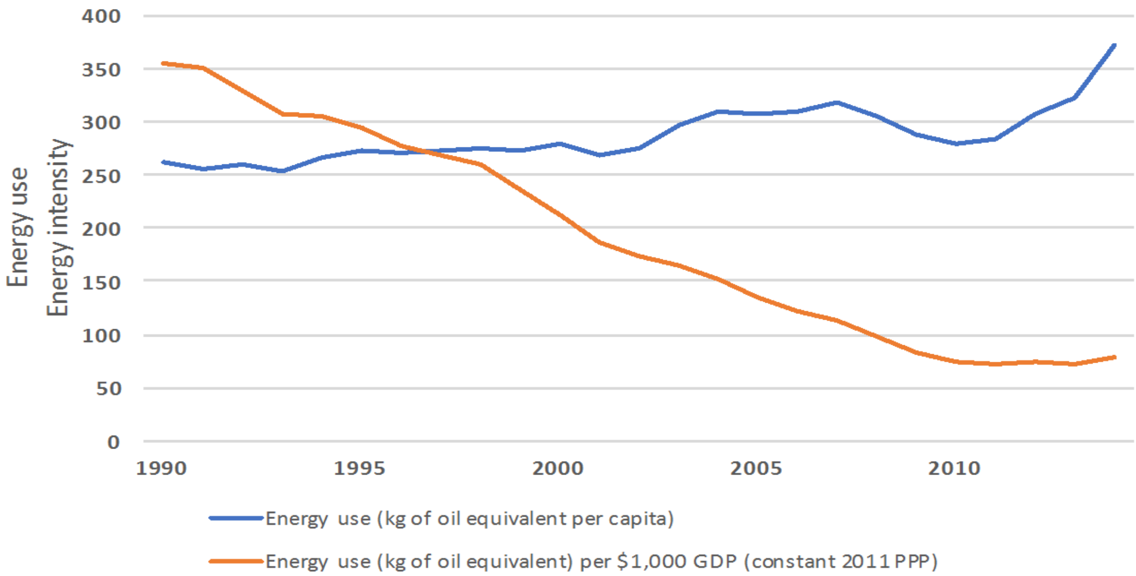
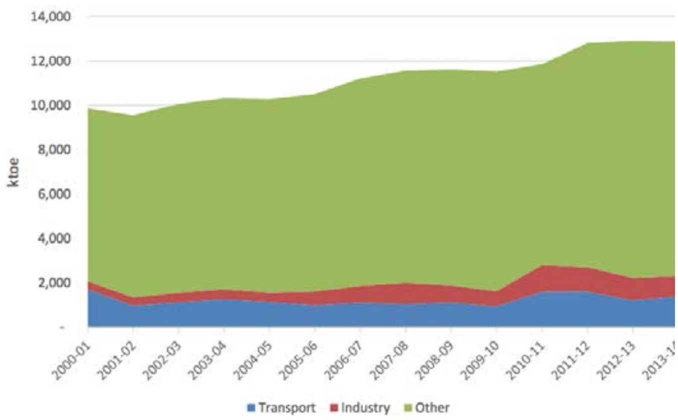


Figure 104 - Energy use, energy intensity 1990 – 2014

(World Bank, 2017b)

Energy consumption in the transport and industry sectors grew over the same period, though growth in other sectors - mainly residential and commercial - has been more important (Figure 105). Energy consumption remains dominated by the rural residential sector, although the share of energy consumption by the sector has declined from approximately 86% in 1992 (UNDP, 1992) to an estimated 63% in 2014. Transport is the next largest consumer of energy, with the productive sectors still accounting for a very small share of energy use.



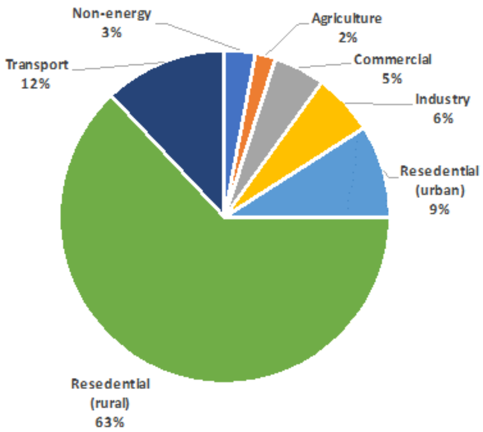


Figure 105 - Total final energy consumption by major sector 2000/2001 to 2013/2014 (a) and total final energy consumption by sector and sub-sector share (%) 2013/2014

(IES and MMIC, 2015)

Energy consumption statistics have not been available for the Ayeyarwady Basin area. The pattern is expected to be similar to the national picture, though the major caveat is that key productive sectors (agriculture, manufacturing, services, etc.) are concentrated within the Ayeyarwady Basin. We expect these sectors to account for a larger share of energy consumption relative to the residential sectors, than is the case nationally. Moreover, given the concentration of these energy intensive sectors and population in the basin, they are likely to account for a disproportionate share of national energy consumption.

8.2.2 *Household energy use in the Ayeyarwady Basin*

a) National trends in household energy use

There is little available information on household energy use. However, available estimates (Figure 114) suggest that the residential sector accounts for approximately 70% of energy consumption nationally. Households typically use energy for cooking, lighting, running various household appliances (televisions, fans, etc.) and in some cases in small scale productive activities. However, figures from the national Energy Master Plan 2015 suggest that on average almost all household energy consumption is accounted for by cooking and water heating (IES and MMIC, 2015).[33]

The high share of residential energy consumption is explained largely by the relative lack of access to modern energy supplies in Myanmar, with one of the lowest per capita commercial energy consumption figures for the region (ADB, 2012). Liquified petroleum gas is not generally available outside urban centres, grid-based electrification rates are low, and the level of services is poor (see Section 8.4 below; IES and MMIC, 2015). As such, households tend to rely on solid fuel stoves for cooking and water heating. The LIFT Baseline Survey in 2012 also reported a similar preponderance of wood-fuel use for cooking in rural areas, with between 90 - 99% of households relying on fuelwood for water heating needs (LIFT, 2012). The proportion of household energy use accounted for by cooking reflects the relative inefficiency of the solid fuel stoves used for cooking relative to modern energy sources.[34]

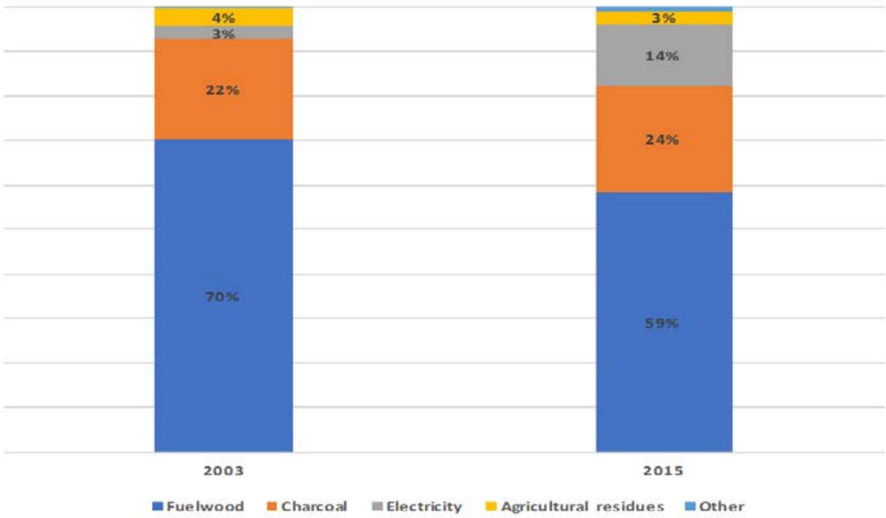


Figure 106 - National household energy sources for cooking, 2003 and 2015

(EMS 2015; World Health Organization [WHO], 2003)

Figure 106 suggests some decline in the use of fuelwood and agricultural residues as a source of fuel, in all likelihood due to improved access to electricity, either through an extension of grid-based service, the development of local mini-grids, or through a higher proportion of the population living in urban areas, which enjoy better access to the grid (see Section 4). At the same time, there is a slight rise in the proportion of households using charcoal. Again this may be explained by the increasing proportion of urban population and the preponderance of charcoal use in urban areas. Whereas in rural areas 80% of households depend on firewood, in peri-urban areas 18% rely on firewood, 45% on charcoal, and 35% on electricity (EMC, 2015). Both

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[33] It is estimated that the proportion of household energy use accounted for by cooking and water heating was 98% in rural areas and 94% in urban areas in 2012.

[34] For example, traditional 'three stone' fires have a thermal efficiency of only approximately 10%, while the more efficient 'mud stoves' available on the delta may have efficiencies of around 17% (EMS, 2015). This compares to efficiencies of modern appliances of greater than 40% for gas stoves, 30% for electrical stoves, and up to 80% for electrical kettles used for heating water.

trends in deceasing fuelwood and increasing charcoal use are typical of energy transitions witnessed in developing countries.

Agricultural residues are a relatively uncommon source of household energy, apart from the Ayeyarwady Delta where the use of rice husks for cooking purposes is more common (EMC, 2015; Mercy Corps, 2011). The progression from more traditional fuels such as fuelwood, which are relatively cheap and readily available, to higher quality energy sources such as charcoal, gas, and electricity is a well-established phenomenon associated with increasing incomes known as the 'energy ladder'.[35]

These changes are also reflected in available data from surveys of household fuelwood consumption. For example, a study in 1996 found average household fuelwood consumption levels of 7.25 t per year in Ayeyarwady and 8.6 t per year in Mandalay Region (Chaw Sein et al., 2015). In 2000, a more extensive survey by the World Bank found lower levels of consumption at 5.35 t per year in Ayeyarwady region, 4.41 in Mandalay region, 4.37 in Sagaing region, 4.87 in Bago region, and 4.37 in Shan State (World Bank, 2000). A 2015 study found even lower levels of fuelwood consumption in Shan State, at approximately 2.67 t per year among rural households, whereas urban households used 1.3 t of charcoal per year (Chaw Sein et al., 2015). However, here we adopt figures cited in ADB documents from 2012 suggesting average annual household fuelwood consumption was approximately 2.25 t in rural areas and 0.7 t in urban areas (Kissinger, 2017).

Additional reasons for the decline in the intensity of fuelwood consumption at households may also reflect the increased price of fuelwood and fuelwood scarcity in some regions, driving more sparing and efficient use of fuelwood, for example through the adoption of more efficient stoves and the more common use of agricultural residues (Chaw Sein et al., 2015).

b) Household energy use in the Ayeyarwady Basin

Data on basic household energy use was gathered in the 2014 census, which included questions on primary source of energy used for lighting and for cooking. Figure 105 provides a comparison of primary cooking fuel usage nationally and in the Ayeyarwady Basin. The only difference is that the Ayeyarwady Basin enjoys a marginally higher share of electricity usage relative to the country as a whole, probably explained by the presence of Yangon and Mandalay - the two largest urban centres within the basin.

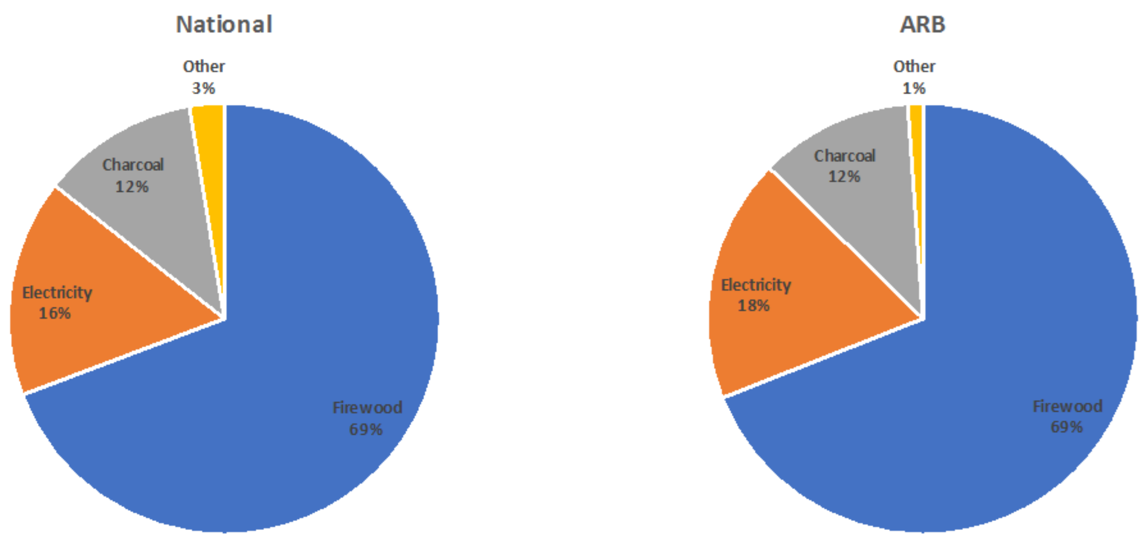

Figure 107 - Household energy use for cooking nationally and in the Ayeyarwady Basin 2014

(Consultants calculations based on census data)

[35] This is also illustrated in choice of secondary fuels among households. Those who rely on fuelwood as the primary cooking fuel tend to rely on charcoal as a secondary fuel source, and those who rely on charcoal as the primary cooking fuel tend to rely on wood or electricity as a secondary fuel choice (EMC, 2015).

8.2.3 Fuelwood and charcoal use

a) The national picture

As the analysis of overall energy production and consumption shows, fuelwood and charcoal are the main sources of energy in the Ayeyarwady Basin, accounting for approximately 43% of energy consumption. Although high, this still represents a marked decline from estimates which put the figure at 87% in 1992 (UNDP, 1992). Aside from household use, fuelwood and charcoal are also extensively used in a variety of production activities including for bricks and ceramics, the production of quicklime, artisanal oil refining, and sugar manufacture. Figures for the extent of these uses have not been available although they are thought to be important.

In addition to domestic use, according to UN Commtrade (2017) figures, Myanmar is one of the world's largest exporters of fuelwood and charcoal, accounting for 2.8% of the global share, at a value of US$ 30.5 million (Kissinger, 2017). In particular, the charcoal trade to China has developed rapidly in recent years, with volumes increasing by over 2,500% between 2006 and 2008. Currently, the charcoal trade with China is at approximately 0.5 M m^3 per year, accounting for approximately one-third of wood product exports to China in 2014 (Forest Trends, 2014).[36] Almost all charcoal imports are registered in Kunming suggesting that the trade is overland and illegal under Myanmar law (Kissinger, 2017). The extent of fuelwood and charcoal export which remains undeclared on the Chinese side is unclear, but judging by estimates on the extent of smuggling of other goods this could be significant, suggesting that the true extent of fuelwood and charcoal exports may be much higher.

Fuelwood is sourced from a variety of different locations including dead trees, pruning, and other woody waste collected from forests, woods, and trees on farming land. It is estimated that approximately 1.5 Mt of fuelwood is produced as a byproduct of the timber industry, although it is not clear how extensively these byproducts are used (IES and MMIC, 2015).

Estimates of overall fuelwood use are uncertain however, there seems to be consensus in the literature that national fuelwood consumption is approximately 19 - 25 Mt (IES et al., 2015; Emerton and Yang 2013). Estimates from Myanmar's draft Renewable Energy Policy in 2016 fall within this range (Figure 108). These indicate high levels of fuelwood harvesting from natural forests, which are estimated to account for approximately 70% of fuelwood supply, with only limited supply coming from fuelwood plantations (5%). This is assumed to be inclusive of wood collected for charcoal, but not include timber industry byproducts. This figure also shows a steady growth in the utilization of fuelwood of approximately 1.9% per year.

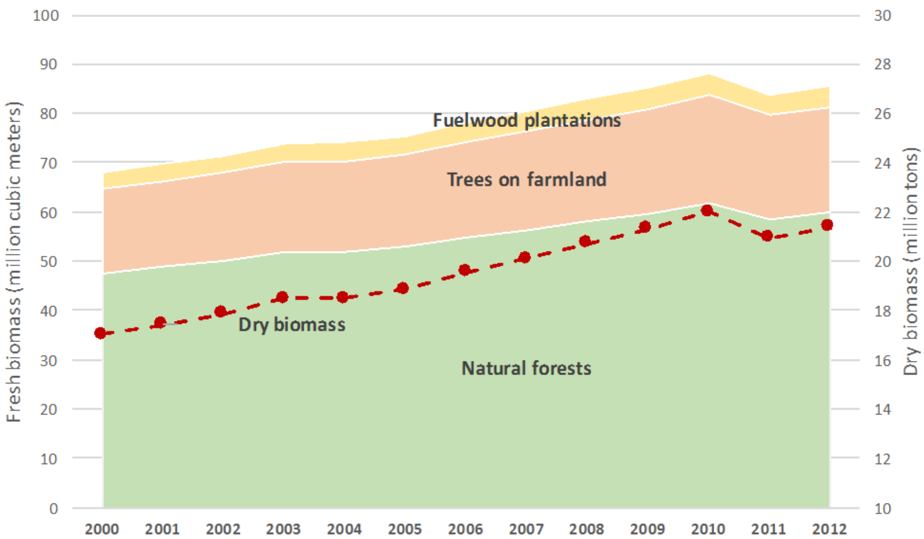

Figure 108 - Estimation of national fuelwood harvest in Myanmar 2000-2012

(Second Draft Renewable Energy Policy of Myanmar, 2016)

[36] The main driver for charcoal demand in China is for the process of smelting silicon for the production of solar panels.

It is unclear if these figures include charcoal production for domestic use, estimated to be between 94,000t and 207,000t per annum (IES et al., 2015; Bailis et al., 2015).[37] The Ministry of Environmental Conservation and Forestry (MOECAF) figures estimate that between 2000 and 2013 charcoal production ran at approximately 240 kilotonnes a year. While production fluctuated over that period, production at the beginning and the end of the period was approximately the same (Figure 109). Figure 109 also gives estimated national fuelwood use for charcoal production. Charcoal production represents an even more inefficient use of fuelwood in that the process is only approximately 14 - 41% efficient.[38] Charcoal production therefore accounts for a large share of fuelwood consumption.

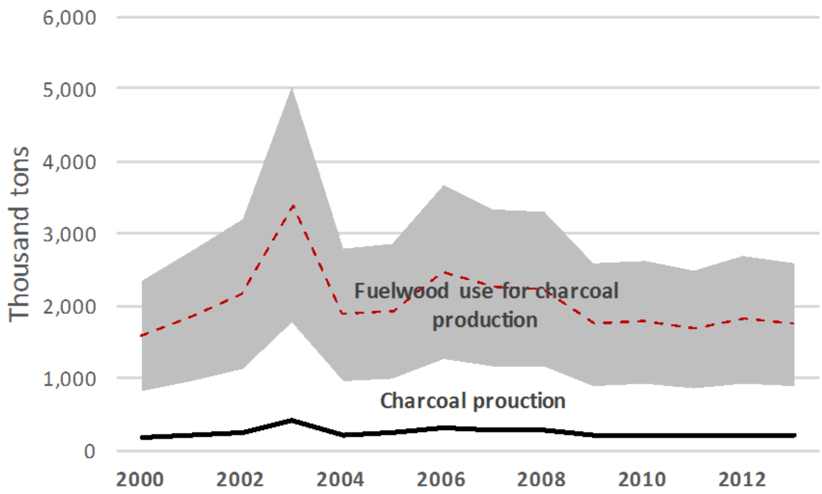

Figure 109 - National charcoal production and implied fuelwood use for charcoal production

(MOECAF and consultant's estimates based on MOECAF and Mercy Corps, 2011)

It is unclear if the cross-border trade in fuelwood and charcoal is accounted for in these figures. As it is informal it is likely missing from official statistics. If so, the charcoal trade alone could add additional fuelwood collection in the region of 1 - 6 Mt. Collection of wood for charcoal production also typically involves felling the whole tree rather than simply branches, and is therefore deemed a more destructive practice (Mercy Corps, 2011).

Despite mixed reports regarding the importance of fuelwood extraction in Myanmar's deforestation, the observation is that annual fuelwood extraction of between 19 - 20 Mt greatly exceeds the estimated available sustainable resource of approximately 10 Mt. Moreover, most fuelwood is harvested from natural forests and limited use seems to be made of waste timber products. It is also clear from available survey data that fuelwood collection is becoming increasing difficult due to forest loss in some areas. We therefore conclude with Kissinger (2017) that fuelwood extraction is likely to be an important driver of deforestation nationally.

b) Fuelwood use in the Ayeyarwady Basin

Patterns of fuelwood use and the role of fuelwood collection and charcoal production in the Ayeyarwady Basin are expected to be similar to elsewhere in the country. From the discussion above several Ayeyarwady Basin regions including Ayeyarwady, Magway, and the Shan states have been identified as areas showing signs of fuelwood scarcity. Also, given the extensive shared border between the Ayeyarwady Basin and China it is likely that the basin sees a substantial proportion of the illegal trade in fuelwood. Finally, it is worth noting that the basin is home to a number of large urban population centres with high population densities,

[37] Here we use the EMP 2015 figures as they are based on government estimates, whereas the figures from Bailis et al. (2015) are based on remote sensing data.
[38] Consultants estimate using energy content per tonne for fuelwood of 0.4091 tonnes of oil per tonne and for charcoal of 0.7356 tonnes of oil per tonne and estimates of conversion rates of fuelwood to charcoal ranging from 8 - 23% by weight (Mercy Crops, 2011).

resulting in the likelihood that the Ayeyarwady Basin sees a disproportionate level of demand relative to the rest of the country.

Figure 110 gives estimates of fuelwood demand across the Ayeyarwady Basin based on national average household fuelwood consumption estimates and population distribution estimates from the census. As such the relative consumption of fuelwood is a function of population and the relative urbanisation of an area, with urban households consuming on average a lower amount of fuelwood.

It important to bear a number of caveats in mind when considering this data. Firstly, using a national average undoubtedly obscures regional differences in fuelwood availability and use. For example, households in areas where fuelwood is plentiful, such as Sagaing region and Kachin state, are likely to use more fuelwood. Secondly, it is not clear whether the fuelwood consumption figures include charcoal use. If not this would mean fuelwood demand generally, and in urban areas in particular, is much higher than indicated by these figures. Finally, these figures are based on the census, which may miss a large proportion of mobile, transient, or otherwise unregistered population. For example, population concentrations in and around areas of ASM, such as the oilfield in Magway, the Mogok ruby tracts, and the jade mining areas in the Uyu River Basin are reputedly significant. These populations will be largely unserved by modern energy supplies and are likely to rely heavily upon fuelwood.

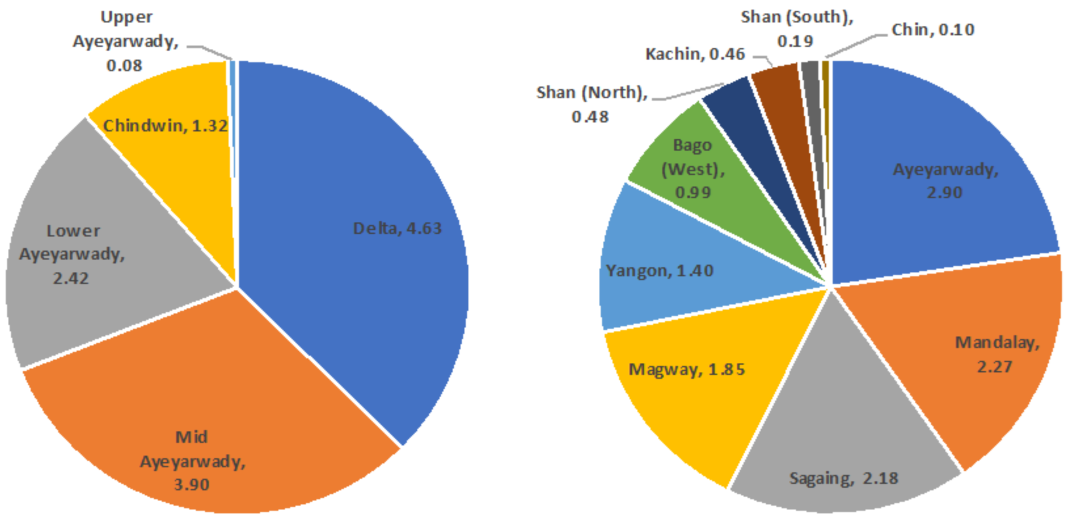

Figure 110 - Estimated annual household fuelwood demand in the Ayeyarwady Basin 2014 (Mt)

(Consultants estimates based on Kissinger 2017, UNFPA 2014)

a) Key issues related to household consumption of biomass, fuelwood, and charcoal use

Energy poverty, defined as lack of access to modern energy sources and reliance on traditional biomass brings with it a range of development problems. Firstly, traditional methods of using biomass for cooking and heating are inefficient,[40] meaning much of the energy potentially available from the biomass is not used to perform useful work, which means much more of the energy source needs to be used than would otherwise be the case. Secondly, the burning of biomass indoors creates problems with indoor air pollution affecting human health through various respiratory conditions. For example, a recent study has found that high levels of indoor $PM_{2.5}$ and carbon monoxide associated with the use of biomass fuels were significant contributors for the prevalence of acute respiratory infections and difficulty with breathing among young children in Myanmar (Rumchev et al., 2015). The WHO has also identified indoor air pollution as a key factor in chronic obstructive pulmonary disease in adults above the age of 30, as well as a moderate link to lung cancer, cataracts, and tuberculosis, and possible links to low birth weight, heart disease, and other forms of cancer (WHO, undated; Gordon, 2014).

Thirdly, biomass collection is frequently time consuming, more so in areas suffering from deforestation such as the delta. For example, rural villagers in the delta were found to spend on average 233 hours annually collecting firewood (Mercy Corps, 2011). This represents a significant opportunity cost. At the same time, it is important to recognize that the collection of fuelwood and production of charcoal are all-important livelihood activities in the Ayeyarwady Basin, particularly for poor households (LIFT, 2012). In some areas fuelwood collection and charcoal making are important means for coping with food insecurity (Woods, 2015). Recent work has shown that over 50% of households buy-in fuelwood for domestic consumption, and this is particularly the case in areas with scarce forest resources such as the Ayeyarwady Delta (EMC, 2015).

Finally, the large-scale use of fuelwood is likely an important driver of deforestation at least in some areas of the Ayeyarwady Basin. Nationally, approximately 28% of households involved in fuelwood collection complained of increasing difficulty in the collection of fuelwood. The highest level of this occurs in the delta, where 38% of fuelwood-collecting households found it more difficult, although households in Magway and Shan State also complained of increasing difficulties. These difficulties were predominantly attributed to decreased availability (EMC, 2015).[39] The recent Energy Master Plan also notes that fuelwood prices in Yangon increased by 2,400% between 1988 and 2004, and charcoal by 1,200% over the same period, which may also be indicative of increasing scarcity, at least in the fuelwood and charcoal production areas serving Yangon (IES et al., 2015).[40]

8.3 Rural Electrification

8.3.1 National context

As noted above, access to electricity remains a critical national development issue. Limited access to affordable and reliable power constrains private sector development and delivery of local services in rural areas. Constrained access to modern sources of energy is also implicated in the reliance of households on biomass energy, and the knock-on consequences of this in terms of inefficient household use of energy, unsustainable levels of fuelwood use, and indoor air pollution (World Bank, 2016a). Even where grid access is available supply is often unreliable (World Bank, 2016a).

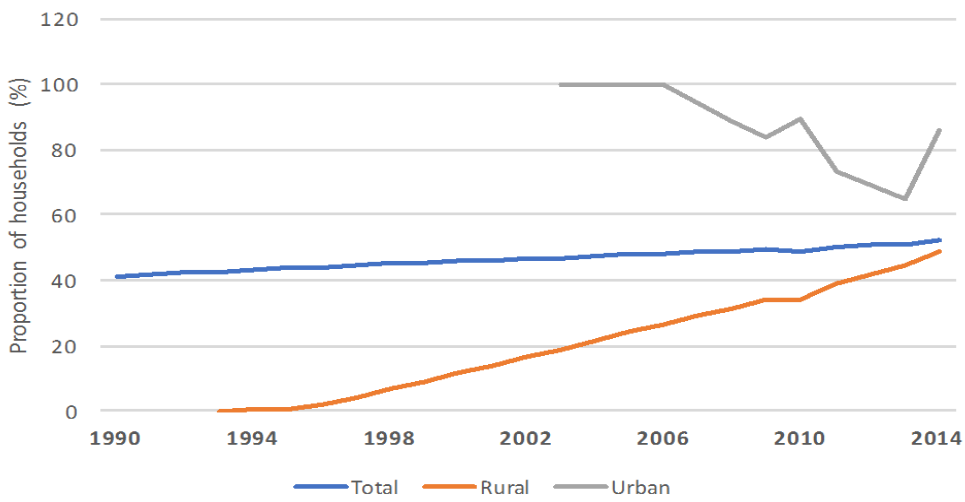

Figure 111 - National household access to grid-based electricity 1990 - 2014

(World Bank, 2017b)

According to national data on household connections approximately 52% of households had access to grid-based electricity in 2014 (Figure 111), with a much higher proportion of urban households (86%) than rural

[39] The EMC study reports that most collection takes place in plantations and from trees on farm land, and not in natural forest areas. It is argued that fuelwood collection is therefore unlikely to be an important factor in explaining deforestation, and similar observations are made in the Energy Master Plan 2015. However, this is at odds with other evidence, for example see Kissinger (2017).

[40] In other places, the EMP 2015 also notes that fuelwood prices have been growing at a rate of around 10% per year between 2000 and 2012 around large urban areas and in the dry zone, which it argues reflects increased income rather than wood scarcity (IES et al., 2015).

households (49%) having electricity access. The time series data suggest that actual urban rates of electrification have declined, which may be due to expansion of urban areas into unserved rural hinterlands, or due to a decline in service. There is also a suspicion that the figures are unreliable. The expansion of access to rural households on the other hand has improved dramatically, increasing significantly from less than a fraction of a percent in the mid-1990s over the intervening two decades.

These figures are likely to over report access to electricity, as they are based on households in communities with access to the grid. In fact, many households in on-grid communities are not connected to the grid due to connection costs or have only intermittent access and require back-up provision (which is the case throughout the Ayeyarwady Basin and nationally).

A better picture of access to electricity is offered by census data.[41] The census reports the number of households with access to electricity for at least some residential uses is higher due to the widespread use of home solar systems, diesel generators, micro-grid systems, and larger scale isolated grid systems in some areas, such as Kachin State. According to census data approximately 31% of households had access to grid-based electricity for lighting, a further 22% of households had access to off-grid electricity for lighting, and 46% relied on kerosene, candles, and batteries. This is supported by figures from Yangon Electricity Supply Corporation and Mandalay Electricity Supply reporting a service level of approximately 65% and 20% of the households in their respective service areas (World Bank, 2016a).

8.3.2 Electrification in the Ayeyarwady Basin

Figure 112 reports census figures on source of lighting for the basin by state/region and by HEZ. The state/region level data illustrates a significant variation in the implied grid-based electrification rate. The predominantly urban areas of Yangon and Mandalay have a significantly higher level of grid-based access at approximately 75% and 40% of households respectively. The lowest levels of grid-based access are in Ayeyarwady region (12%) and Chin state (17%). The other predominantly rural regions in the Ayeyarwady Basin have similarly low levels of grid-based connection, including south Shan state (20%), Magway region (23%), Sagaing region (24%), Kachin state (30%), Bago region (25%), and north Shan state (33%). Similar patterns can be seen in the HEZ, although it should be noted that the inclusion of large urban areas in the Delta and Middle Ayeyarwady suggests a higher level of electrification than is actually the case in much of the HEZ area.

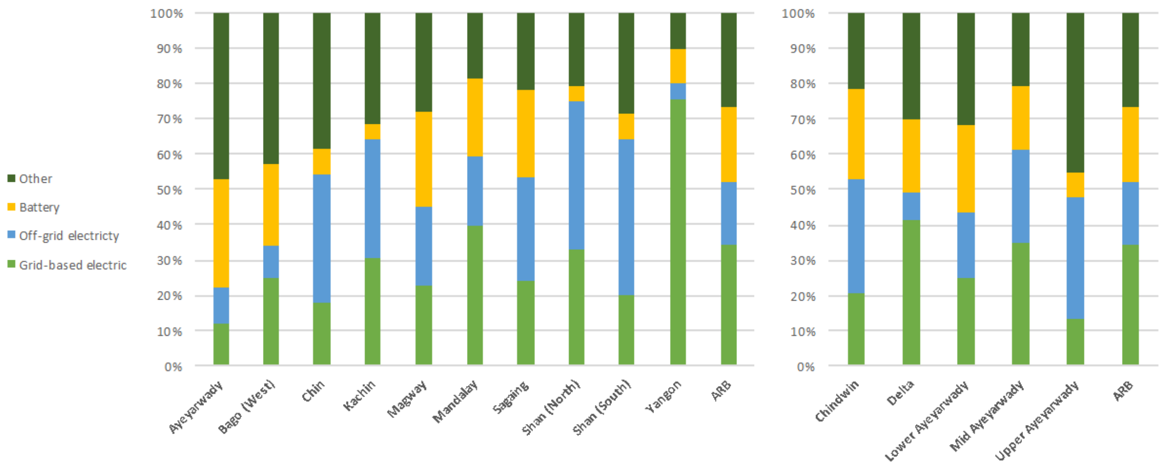

Figure 112 - Source of household lighting in the Ayeyarwady Basin by state/region and by hydro-ecological zone, 2014

(Consultant's estimates based on UNFPA 2014)

41 The figures from the census report the primary source of household energy for lighting and cooking. In many cases secondary sources may be important but are unreported. This is probably particularly the case for cooking, for which electricity is in a fair proportion of cases likely used as a secondary energy source. Thus the proportion of households using electricity as the primary energy source for cooking is likely to under-report actual access to electricity, at 15%. By contrast, if available, on-grid electricity is typically the first choice of energy for household lighting. Therefore figures on the primary energy source for household lighting are a good guide to the actual extent of access to electricity.

The census figures also serve to emphasize the importance of off-grid electricity provision in some areas. Notably Shan state (north; 44%), Shan state (south; 42%), Chin state (37%), Kachin state (34%), and Sagaing region (29%), where off-grid provision is more important than on-grid. This is probably explained by both remoteness from the central grid system, but also the availability of other off-grid electricity resources (mainly diesel generators, biomass generators, household solar, and small and micro-hydro power plants in these mountainous areas). In terms of poorest access to all types of electricity (including on-grid and off-grid), Ayeyarwady and west Bago regions have the lowest levels of household access at 22% and 34%, respectively.

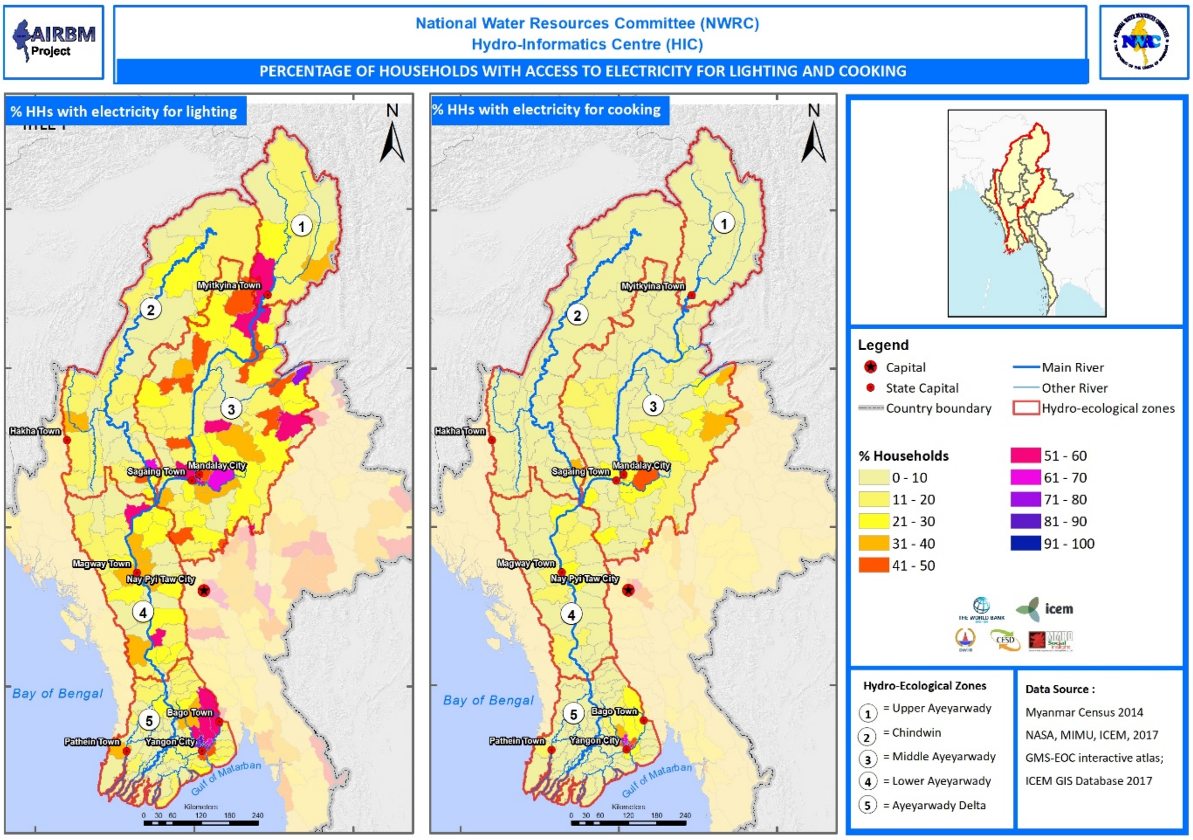

Figure 113 - Proportion of households with grid-based electricity for lighting and cooking (%), 2014

(UNFPA 2014)

Spatially disaggregated figures for the Ayeyarwady Basin serve to reinforce this pattern. Areas in and around urban centres trend to be well served, but with more remote and rural areas with generally poorer access to the grid. Figure 113 serves to emphasize the spatial disparity in access to modern energy resources noted above. It is interesting to note that the highest township levels of electrification actually lie in the international border with the PRC. The figures for cooking seem to be a less reliable indicator for grid access, as they are likely to miss households that use electricity as a secondary source of energy for cooking. The figures may also conflate grid access with access to other energy resources - that is, in large urban areas where grid-based electricity is more widely used for cooking this may be a partial consequence of the scarcity or relative expense of other fuels relative to other areas.

b) Distributed generation, micro-grids, and rural electrification

National planning priorities remain focused on the development of large-scale centralized generation assets supplying a national grid. However, in the absence of state provision in many rural and smaller urban areas, the domestic private sector has become an important provider of electricity services. As noted above (Section 8.3.2) in some areas of the Ayeyarwady Basin off-grid provision is significantly more important than on-grid service provision. Based on the census data, assuming that all households that identify either private generators or water mills (small hydro) as part of mini-grids, then over the whole basin approximately 10% of households are supplied by mini-grids (Figure 114). This is broadly consistent with DRD data which identifies 16,700 villages supplied by mini-grids nationwide (Greacen, 2016).

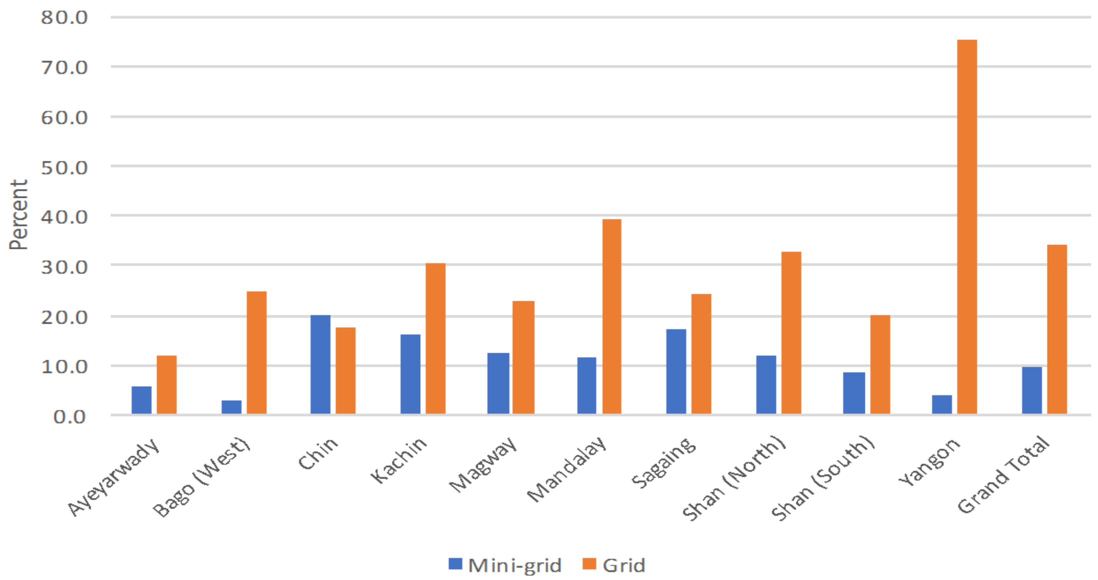

Figure 114 - Comparing mini-grid and grid based electricity access in the Ayeyarwady Basin, 2014

(UNFPA 2014)

The Ayeyarwady Basin has seen significant development of mini-grids, developed by and large by domestic entrepreneurs. Diesel generators are most common, using small single or three phase Chinese-made units. Hydropower is concentrated in Shan state, Mandalay region, and Sagaing region, and biomass gasifiers are common in rice growing areas. It is estimated that approximately 6,000 small HP plants and 10,000 biomass gasifiers are in operation. Solar PV and solar/diesel hybrid technologies are relatively uncommon, with dozens of systems in operation nationally, and more in the development pipeline (Greacen, 2016).

Typically, these mini-grids rely initially on the provision of an electricity service to an anchor user (such as a rice mill), and the service is then extended to households and other productive uses within the community. Opportunities exist for the further expansion of mini-grids as an alternative to interconnection to the central grid, depending upon resource availability, demand considerations and grid-connection costs in different locations (Greacen, 2016). There are significant potential opportunities, given both Myanmar's ambitious electrification targets, and the remote location of many sources of demand. For example, as noted in a recent report on the power sector, forecasts project that by 2017 approximately 9,900 telecommunications sites in Myanmar will be viable for renewable power generation - as potential anchor users for mini-grid development (Doberman, 2016).

c) Key issues related to rural electrification

Access to modern energy is an important element of development. First, it is important as it relates to issues addressed in Section 3.3.3 on the reliance on traditional biomass; better access to electricity is likely to reduce reliance on traditional energy sources, and related issues. Second, electrification is an important element of community development. The low level of electrification in the Ayeyarwady Basin is likely to represent an important constraint on economic development and the provision of local services. Currently, electrification is constrained by the lack of financial resources. Current electrification plans targeting 100% electricity access by 2030 are deemed ambitious.

8.4 National Context

a) National power consumption

Between 2000 - 2001 and 2013 - 2014, on-grid power consumption grew by nearly 200%, from 3.3 terawatt hours (TWh) in 2000 - 2001 to 9.6 TWh by 2013 - 2014. This is equivalent to an AAGR of approximately 9%.

Growth seems to have accelerated significantly between 2009 - 2010 and 2013 - 2014 to a rate of 13.6% (IES et al., 2015). Despite the rapid growth in consumption, grid-based electricity consumption is approximately 160 KWh per capita, approximately 5% of the world average in 2013 - 2014 and remains low by international and regional standards (Figure 115; World Bank, 2016a). Given low levels of electrification and the reliance on isolated supply for off-grid supply and for grid-back-up, a considerable portion of demand for modern energy services is unmet through grid-based provision.

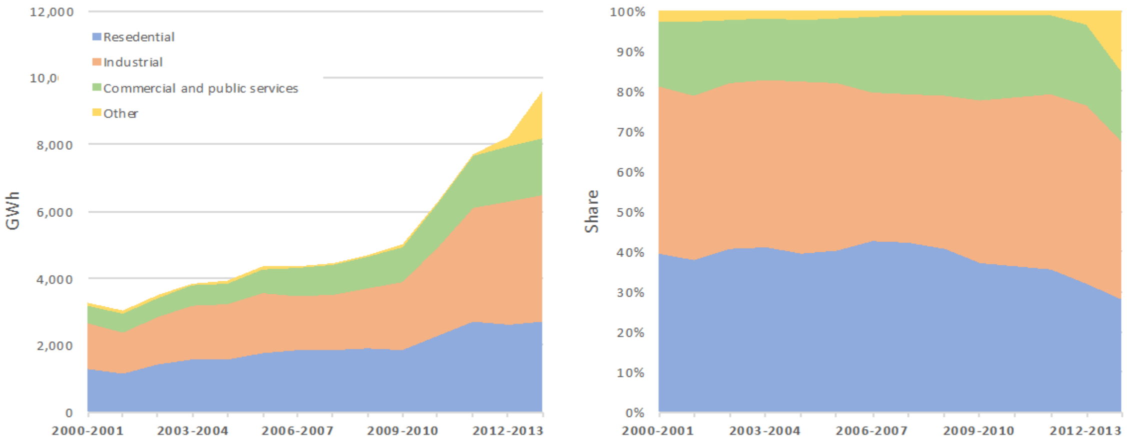

Figure 115 - Power demand by sector 2000 - 2001 to 2012 - 2013

(IES et al., 2015)

These figures probably underestimate consumption. First, some portion of T&D losses are likely to be due to non-technical losses, as available data does not distinguish between technical and non-technical losses. Second, supply from isolated sources is likely to be significant. Micro and localized grids are common in rural areas, and in urban areas and at industrial facilities back-up generators are ubiquitous.[42] The World Bank estimates that 22% of households have access to off-grid, high-cost, low-reliability electricity supply. There are no figures on the number of back-up generators in the country.

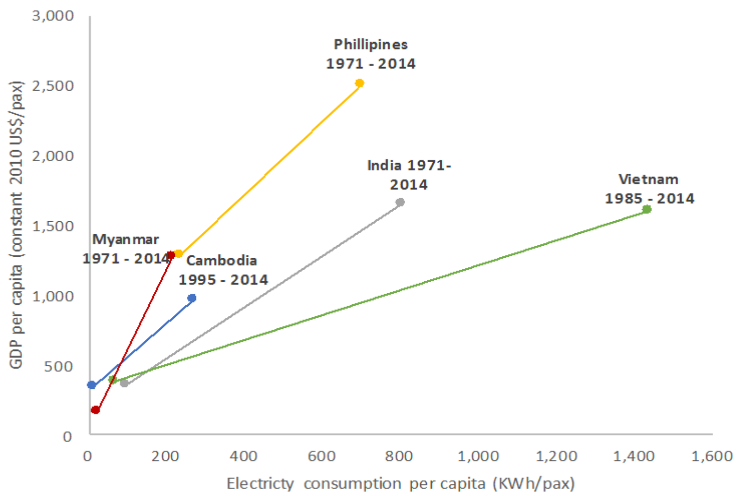

Figure 116 - Myanmar and selected regional countries electricity consumption and GDP per capita

(World Bank, 2017b)

[42] Figures from 2013 suggest that there was approximately 116 MW of off-grid or isolated capacity, of which 78 MW is diesel (see Win, U.T. 2015. Opportunities and Barriers of Power Development in Myanmar. Presentation). This seems an underestimate, as based on a typical household generator rating of 20 kVA, this would mean there was only approximately 4,900 gensets in the country, which is low compared to estimates for Cambodia.

All sectors have seen a rapid growth in the consumption of grid-based electricity. In 2012 - 2013, the Myanmar Energy Master Plan estimated final consumption by sector as 44% for the industrial sector, 32% for the residential sector, and 20% for the commercial sector.[43] Consumption in all three sectors has grown rapidly over the last decade, although growth in industrial consumption accounts for the lion's share of consumption growth, followed by the residential sector and the commercial sector (**Figure 116**).

b) Drivers of demand

Growth in demand for electricity is associated with rapid economic growth. In particular, growth in more energy intensive sectors such as manufacturing has led to increased electricity demand. Second, while the overall number of households connected to the national grid remains low it is increasing quickly. In 2010 - 2011 only 25% of households had a grid connection, by 2015 - 2016 the figure had increased to approximately 34% of households. This represents a growth in household connections of approximately 296,000 per year (Wang and Win, 2016). At the same time income growth and increased household consumption is growing the demand for energy services and electricity per household (as ownership of air conditioners, refrigerators and other household goods increases). Myanmar is not only seeing increasing electricity demand due to general expansion of the economy, but also an increase in the intensity of electricity use. In 2010, GDP per kWh was approximately US$ 7.6 (2010 constant prices), in real terms this figure has shrunk to US$ 5.2 by 2015 - representing an increase in electricity intensity of approximately 30%.[44]

c) National power generation

Gross electricity generation has more than doubled over the last 13 years, from 5,118 gigwawatt hours (GWh) in 2000 - 2001 to approximately 12,278 GWh in 2013 - 2014, equivalent to an AAGR of 6.5% (Figure 117). Approximately 97% of this increase in production has come from the expansion of HP. Hydropower's share of generation has increased from 37% in 2000 - 2001 to approximately 72% in 2013 - 2014. The remainder is comprised largely of gas fired generation, which has expanded from 2,500 GWh (49% of production) in 2000 - 2001 to approximately 2,800 GWh (23% of production) in 2013 - 2014.

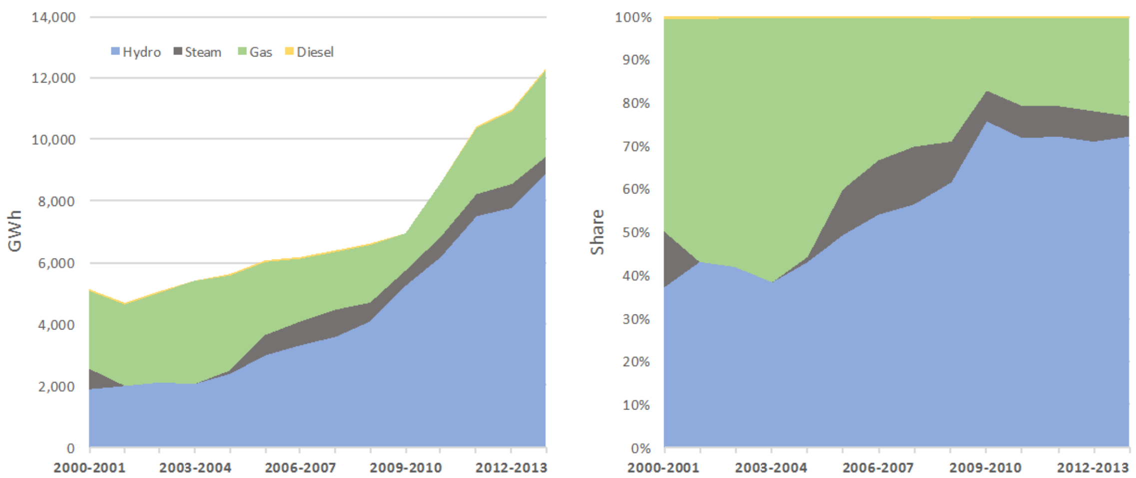

Figure 117 - Electricity production by generation technology 2000 - 2001 to 2013 – 2014

(IES et al., 2015)

This pattern of increasing dominance of HP in the energy sector is reflected in the growth of installed capacity. Between 2000 - 2001 and 2013 - 2014, capacity additions have been dominated by HP, accounting for 2.3 GW of new capacity. This includes the commissioning of several large HPPs including Paunglaung (280 MW) in 2005, and in the Ayeyarwady Basin Shweli (600 MW) in 2008, Yeywa (790 MW) in 2010, and Dapien (240 MW) in 2011. That growth compares to approximately 50 MW of new gas capacity and the 120 MW Tigyit coal plant commissioned up until 2013 (Nam et al., 2015). Investment in gas has since increased substantially

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43 These figures do not account for the 'other' category, which remains unexplained.
44 Based on World Development Indicators GDP figures and MOEE power demand figures.

with the commissioning of approximately 650 MW between 2013 and 2016. In 2015/2016 installed capacity stood at 5,235 MW (OBG, 2017).

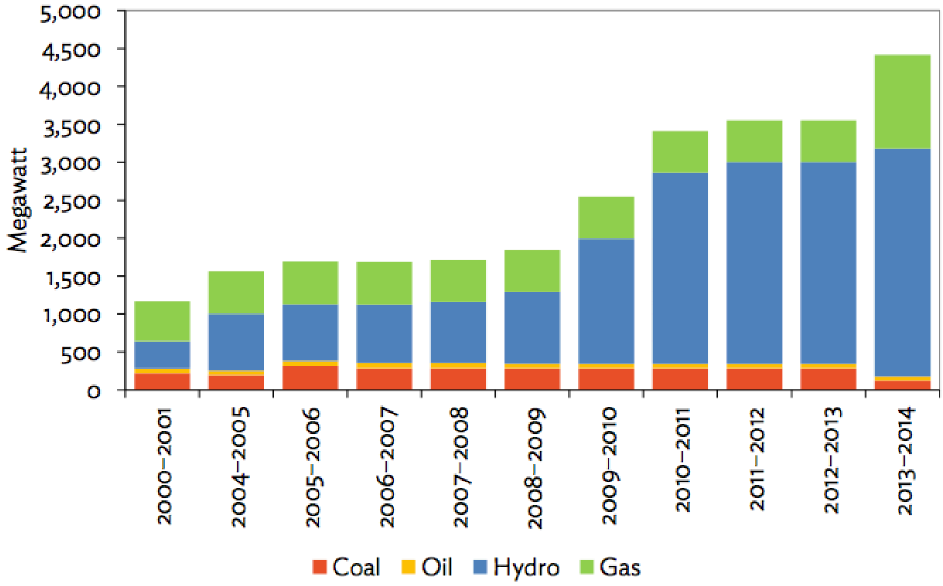


Figure 118 - Installed capacity by generation technology 2000 - 2001 to 2013 - 2014

(Nam et al., 2015)

Peak load grew at approximately 6.5% between 2000 - 2008 and growth accelerated approximately 15% a year between 2009 and 2014. Peak load in 2014 was an estimated 2,400 MW (Figure 119). Peak load in 2013 - 2014 was only a little over half installed capacity of approximately 4.5 GW, electricity supplies have been dogged by load shedding and black-outs (Posner-Ross, 2015).[45]

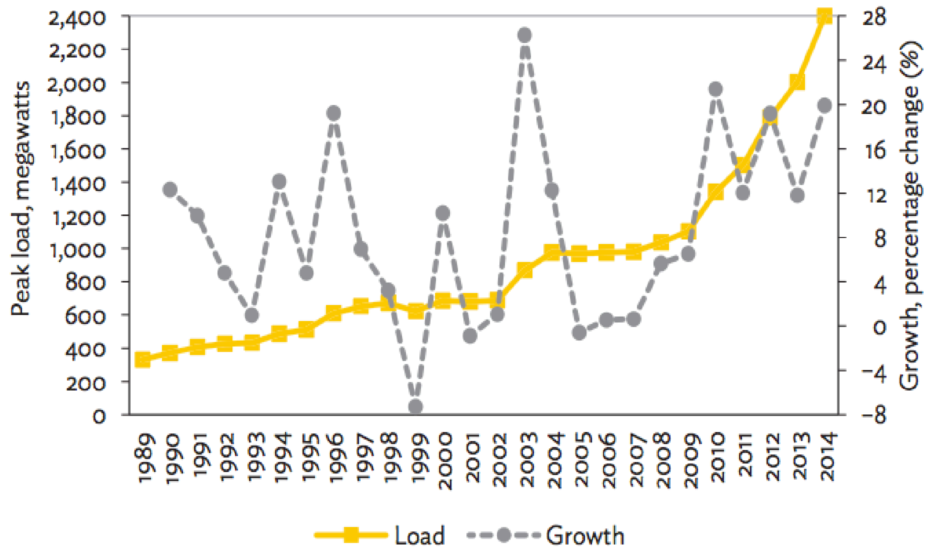


Figure 119 - Peak load growth, 1989 - 2014

(Nam et al., 2015)

Figure 120 shows the demand supply gap over the last six years, at approximately one-third in 2012 and 2013. The large and persistent gap between peak demand and firm power is due to the rapid growth in power demand over the last decade, the cumulative impact of delays in power sector infrastructure investment,

45 According to a recent World Bank report, due to load shedding, the 'realised peak' was only around 2.1 GW. See World Bank, 2016, Electrifying Myanmar: Challenges and opportunities planning nationwide access to electricity. Washington D.C.

and an over-reliance on seasonally available HP. Low reliability, load shedding, and blackouts remain problems despite the recent additions in HP and gas capacity (World Bank, 2016a).

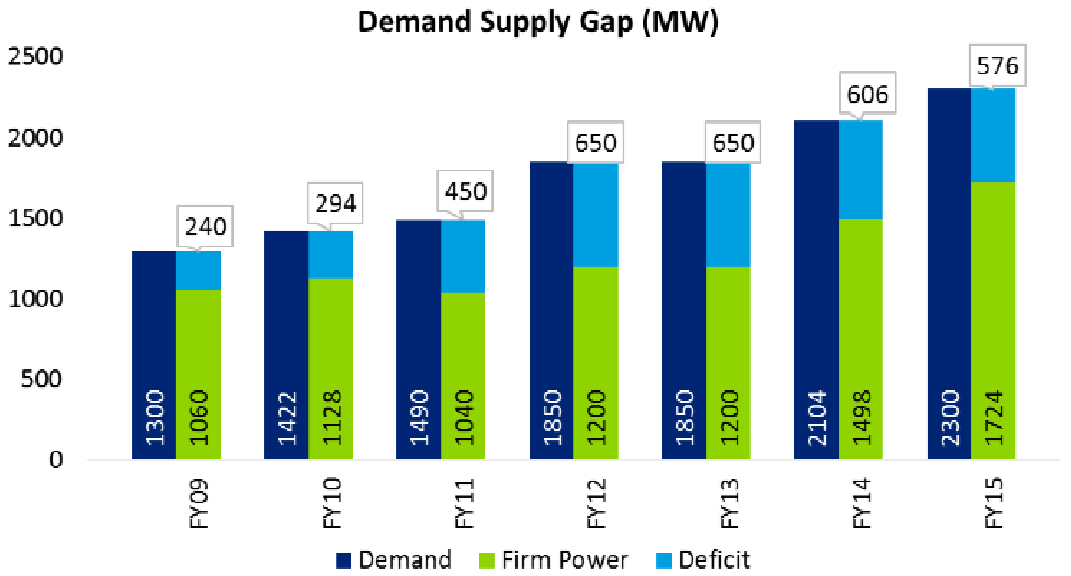


Figure 120 - Demand supply gap 2009 - 2015

(Deloitte, 2015)

Apart from shortfalls in generation capacity (from breakdowns and the seasonality of HP) underinvestment in T&D infrastructure has led to large-scale T&D losses (Posner-Ross, 2015). T&D losses have decreased from approximately 30% in 2000 - 2001 to approximately 20% in 2012 - 2014. Nevertheless, these are still very high at approximately 2.4 TWh, of which approximately 70% take place in the distribution network, and the remainder on the transmission network (NEMC, 2014).

d) Transmission and distribution

Aside from generation shortfalls the T&D system in Myanmar and the Ayeyarwady Basin has problems. Overall T&D losses (including technical and non-technical losses) are estimated to be approximately 21% of production in 2014, which represents a decline in the proportion of losses from 2001 when they stood at approximately one-third of generation. However, in absolute terms, as a consequence of increased generation, actual power losses have increased over the period from approximately GWh 1,600 in 2001, to GWh 2,580 in 2014 (World Bank, 2017b; Figure 119).

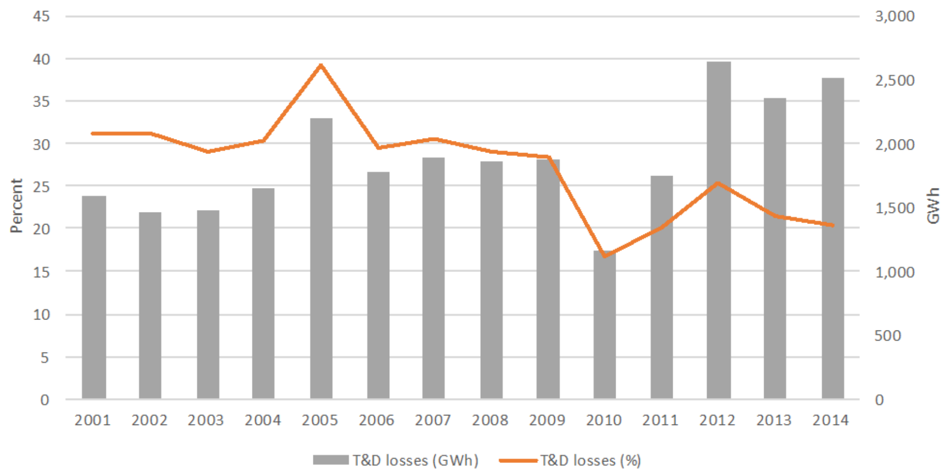


Figure 121 - T&D losses 2001 - 2014
(World Bank, 2017b)

Aside from power losses, which are significant, poor T&D infrastructure together with inadequacies in generation also has a severe impact on the quality of supply. The extent to which power outages, load shedding, and voltage fluctuations are a consequence of inadequate generation capacity or attributable to inadequacies in T&D infrastructure is indicated by data on Yangon collected for 2013. This suggests that approximately 35% of outages (24% of outage time) were explained by load shedding, 16% (24%) by maintenance operations, and approximately 49% (52%) due to line faults and various other faults with the T&D network (JICA, 2013).

On average, businesses reported 12.5 outages per month in 2014, and a loss of 2.5% in sales attributed to power cuts in 2014, according to World Bank data (World Bank, 2017a). Data on Yangon from JICA highlights poor service experienced by many users, for example in 2013 the 15 IZs around Yangon only received power from the grid for 5 hours a day even during rainy season, and during May 2013 all IZs went without power for a month. As a result, IZs reply on isolated generation plants (JICA, 2013). Indeed, diesel back-up generators are ubiquitous across urban areas in the Ayeyarwady Basin.

There are extensive plans to upgrade and improve T&D infrastructure to address these problems, including the expansion of the national grid to most of the country by 2031 as well as the upgrading and improvement of low and medium distribution networks in areas that already have grid service, with a priority on the main urban centres of Yangon and Mandalay. Figures on the planned expansion of the national transmission grid are included in Table 78. A significant expansion of the high-voltage transmission network is envisaged, with approximately 2,400 km of 500 kV lines and 7,600 km of 230 kV lines planned for the 2013 - 2031 period.

Table 78 - Summary of national transmission expansion plan 2013 - 2031

(Maung Maung Kyaw, 2017)

Type	2013 - 2016		2017 - 2021		2022 - 2026		2027 - 2031	
	Length (km)	MVA[46]	Length (km)	MVA	Length (km)	MVA	Length (km)	MVA
500 kV	269	1,500	1,211	5,000	481	1,000	402	-
230 kV	2,957	2,700	3,160	4,010	589	1,150	-	700
132 kV	96	990	97	0	71	260	81	300
66 kV	2,206	641	1,381	405	150	150	483	75

It is unclear the extent to which the first stage of these plans has been realized. Nor is it clear the extent to which the development of the transmission system is contingent upon or otherwise related to the development of HPPs and the need to transport power from projects in Kachin and Shan states in the north of the Ayeyarwady Basin to the load centres of Mandalay and Yangon. It is likely that most of the planned transmission network is based on the need to establish an effective national grid - for example, linking the currently isolated systems around Yangon and Mandalay along with other population centres - rather than transport power from HPPs to the grid.[47]

Given the uncertainty surrounding power development plans and the seemingly ad hoc nature of HP development in the Ayeyarwady Basin (and nationally) it seems unlikely that grid expansion plans could incorporate such considerations other than at a very general level.

8.4.1 Power generation in the Ayeyarwady Basin

As it is home to Myanmar's largest population centres and centres of industrial production, the Ayeyarwady Basin is the location of the country's largest load centres. Most of Myanmar's grid-connected generation assets are situated in the Ayeyarwady Basin. Figure 120 illustrates their locations and related energy supply infrastructure.

[46] Millivolt-amperes.

[47] Most transmission lines from large HP projects to the grid are 230 kV; it is unclear whether the figure here includes these transmission lines.

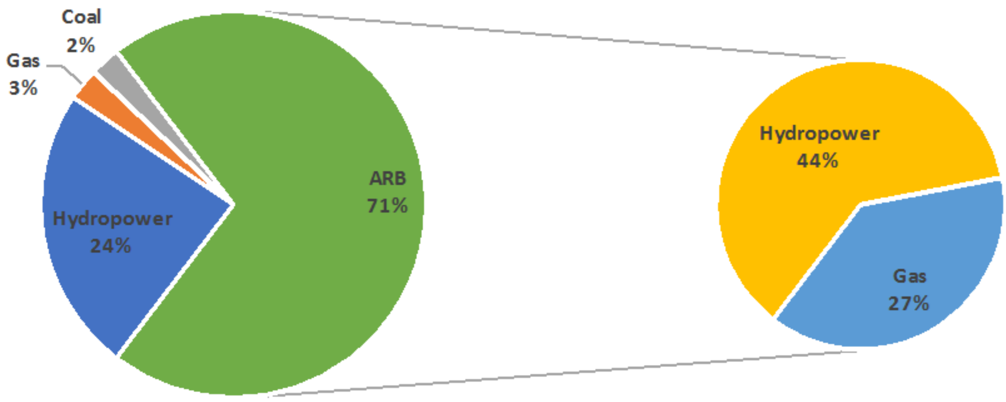


Figure 122 - Share of national power generation capacity (a) in the Ayeyarwady Basin (b) by type, in 2015

(Deloitte, 2015; ICEM, 2017)

At present, planning for the power sector and generation expansion in particular is in a state of flux. There is a recognition that the significant shortfalls in power generation need to be addressed as a matter of priority, but there remain competing visions regarding what might represent a suitable mix of generation technologies. This reflects among other things, general government financial constraints and issues relating to the financial sustainability of the power sector, and above all social, environmental, and political considerations relating to the potential impacts from the development to generation plants. Hydropower and coal plants represent a particular concern due to the potential environmental and social impacts of these developments (ICEM, 2017; WWF, 2016). In what follows, we give a brief description of current coal and gas capacity in the Ayeyarwady Basin. Section 8.5.3 looks at the HP sector in the Ayeyarwady Basin in greater detail.

a) Gas

With the exception of plants in Mawlamyine and Mon State, all the country's gas fired power capacity is situated in the Ayeyarwady Basin close to the major onshore gas fields and supply pipelines. Table 79 lists the gas fired plants in the basin.

Table 79 - Location, capacity, and ownership of gas plants in the Ayeyarwady Basin in 2015

(Deloitte, 2015)

Plant name[48]	Location	Installed capacity (MW)
Myanmar Electric Power Enterprise		
Hlawga CCGT	Yangon	154.2
Ywama GT	Yangon	70.3
Ahlone CCCT	Yangon	154.2
Tharkayta CCGT	Yangon	92
Kyuchuang GT	Monywa	54.3
Myanaung GT	Ayeyarwady	34.7
Shwedaung GT	Bago	55.35
Mann GT	Magway	36.9

[48] CCGT - Combined cycle gas turbine; GT - Gas turbine; IPP - idenpendant power producers.

Plant name[48]	Location	Installed capacity (MW)
Ywama 240	Yangon	240
IPP		
Myanmar Central Power Co. Ltd. - Hlawga	Yangon	26.65
Toyo Thai Power Myanmar Co. Ltd. - Ahlone	Yangon	94
UPP Power Myanmar Co. Ltd. - Ywama	Yangon	52
Max Power Co. Ltd. - Thaketa	Yangon	53.58
Rental		
Kyauk Se	Mandalay	110.63
Total		**1,228.8**

b) Coal

Currently there are no operating coal-fired plants in the Ayeyarwady Basin. However, a large 600 MW plant is under construction at Kalewa in the Chindwin River Basin. This is associated with the significant sub-bituminous coal deposits located there (see Section 2.4.3). Moreover, there are a number of coal plants under consideration in the basin, including over 3,000 MW at a large complex in Kungyangun Township and another 500 MW plant at Kyauktan in Yangon, 660 MW in Pathein in Ayeyarwady, and 500 MW in Mandalay. At present, most of these plants are in the early stages of development and it is unclear which plants will be constructed on what timeframe.

c) Key issues relating to thermal power development in the Ayeyarwady Basin

The limited development of thermal plants in the Ayeyarwady Basin means there is limited impact on the basin from their development thus far. Nevertheless, as the sector develops and more thermal plants are constructed it will become increasingly important to ensure issues of pollution control (water, land, and air) and water use are properly addressed. Thermal plants are all significant water users, and these needs will need to be balanced against other water users particularly in water constrained areas during the dry season. Pollution emissions are likely to present a more important consideration. Coal plants produce significant emissions to air, water, and land. The combustion of coal produces a range of air pollutants ranging from PM, to Nitrogen and Sulphur oxides, greenhouse gas emissions, and heavy metals (such as Mercury). Water pollution can result from leachate from coal storage heaps (coal-pile run-off), ash, and used water from the power plant (boiler blowdown, cooling process wastes, boiler cleaning wastes, treatment effluents, and thermal pollution). Emissions to land include fly-ash and bottom-ash, oil/chemical spills, metals, and other wastes. Gas thermal plants present similar problems with thermal pollution from waste water, air pollutants (particularly greenhouse gass emissions and NO_x), and oil and chemical spills - although they are much cleaner than coal plants. These will need to be carefully controlled and monitored with the development of the sector.

8.4.2 HP in the Ayeyarwady Basin[49]

a) Overview of Ayeyarwady Basin HP plants existing and planned

The Ayeyarwady Basin is home to 14 existing HP plants with a further 32 plants planned. The location and size of these plants in the basin is illustrated in Figure 123.[50] Total installed capacity in the basin is approximately 2.1 GW approximately 46% of installed generation capacity and 64% of total installed HP capacity in the country. If all currently proposed plants are built in the Ayeyarwady Basin this would represent a total installed capacity of approximately 28,100 MW, or 58% of the national HP capacity currently under consideration. Figure 119 gives the cumulative installed capacity for the current pipeline of plants, though it

[49] It should be noted that the following analysis draws heavily on the IFC sponsored SEA of HP in Myanmar (ICEM, 2017).

[50] This only includes HPPs of greater than 10 MW in capacity. This also includes the controversial and suspended Myitsone project in Kachin State.

should be noted that this excludes the Myitsone and Sedawgyi plants, which have no given commercial operations date; in the case of Myitsone this is due to its current suspension.

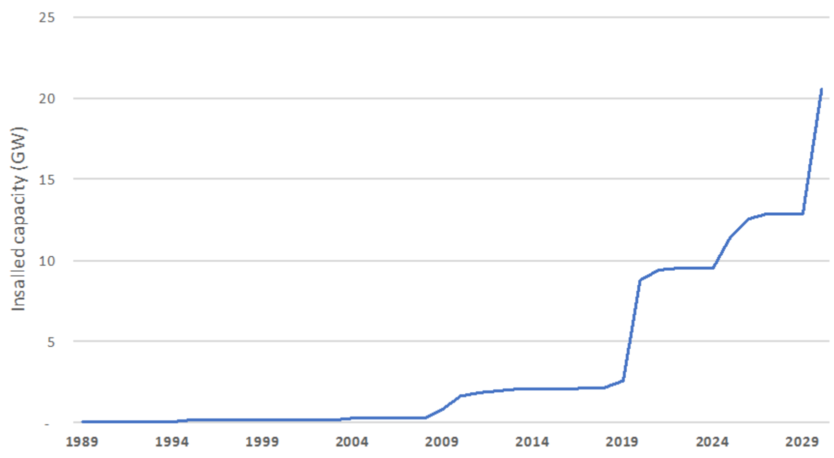


Figure 123 - Cumulative installed HP capacity in the Ayeyarwady Basin, 1989 - 2017 (actual) and 2018 - 2030 (MOEE plans, ICEM, 2017)

Existing and proposed plants are concentrated in the upland, mountainous areas of Kachin State and the Upper Ayeyarwady in the north of the Ayeyarwady Basin, the Middle Ayeyarwady Basin in Shan State, and Mandalay Region. Fewer projects are located in the Lower Ayeyarwady and Chindwin HEZs. Currently, the Middle Ayeyarwady HEZ hosts the majority of HP projects with 10 existing projects, two under construction and a further 11 projects planned, together totaling an installed capacity of approximately 5.3 GW. The Upper Ayeyarwady currently only has one HP project at Chipwi Nge, and an additional 13 are at some stage in the development and planning process. Together these total over 20 GW. Even excluding the 6 GW Myitsone Dam, there are six further projects with capacities exceeding 1,000 MW in the development pipeline. By comparison HP development in the rest of the Ayeyarwady Basin generally consists of smaller plants, although the plant at Shweli (1,050 MW), Shweil 2 (600 MW), Yewa (790 MW), and Middle Yewa (700 MW) are large plants.

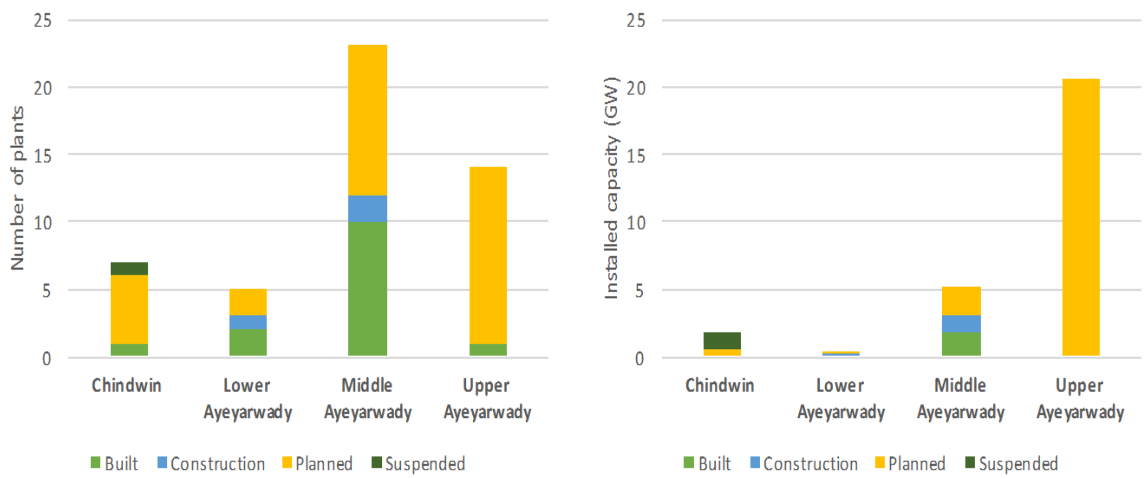


Figure 124 - Current and planned HP plants in the Ayeyarwady Basin by hydro-ecological zone *(ICEM, 2017)*

The scale of development is illustrated by the storage volume of the HP plants and the size of reservoirs. Figure 124 reports the cumulative storage capacity and reservoir area of existing and planned plants in the Ayeyarwady Basin. At present cumulative HP storage is approximately 10,542 cubic hectometres (hm^3), if all projects are developed this will increase to at least 73,500 hm^3, an increase of approximately 600%. Similarly, the area of HP reservoirs in the basin will increase from approximately 661 km^2 to at least 2,251 km^2, or approximately 240%. Considering the differences between HEZs (Figure 125), most of the storage is likely to be situated in the Upper Ayeyarwady, then the Chindwin and Middle Ayeyarwady. Reservoir area is roughly evenly distributed between the Upper Ayeyarwady, the Middle Ayeyarwady, and the rest of the Ayeyarwady Basin. It should be noted that the figures for the Chindwin are dominated by the 1.2 GW Tamanthi project, which is currently suspended.

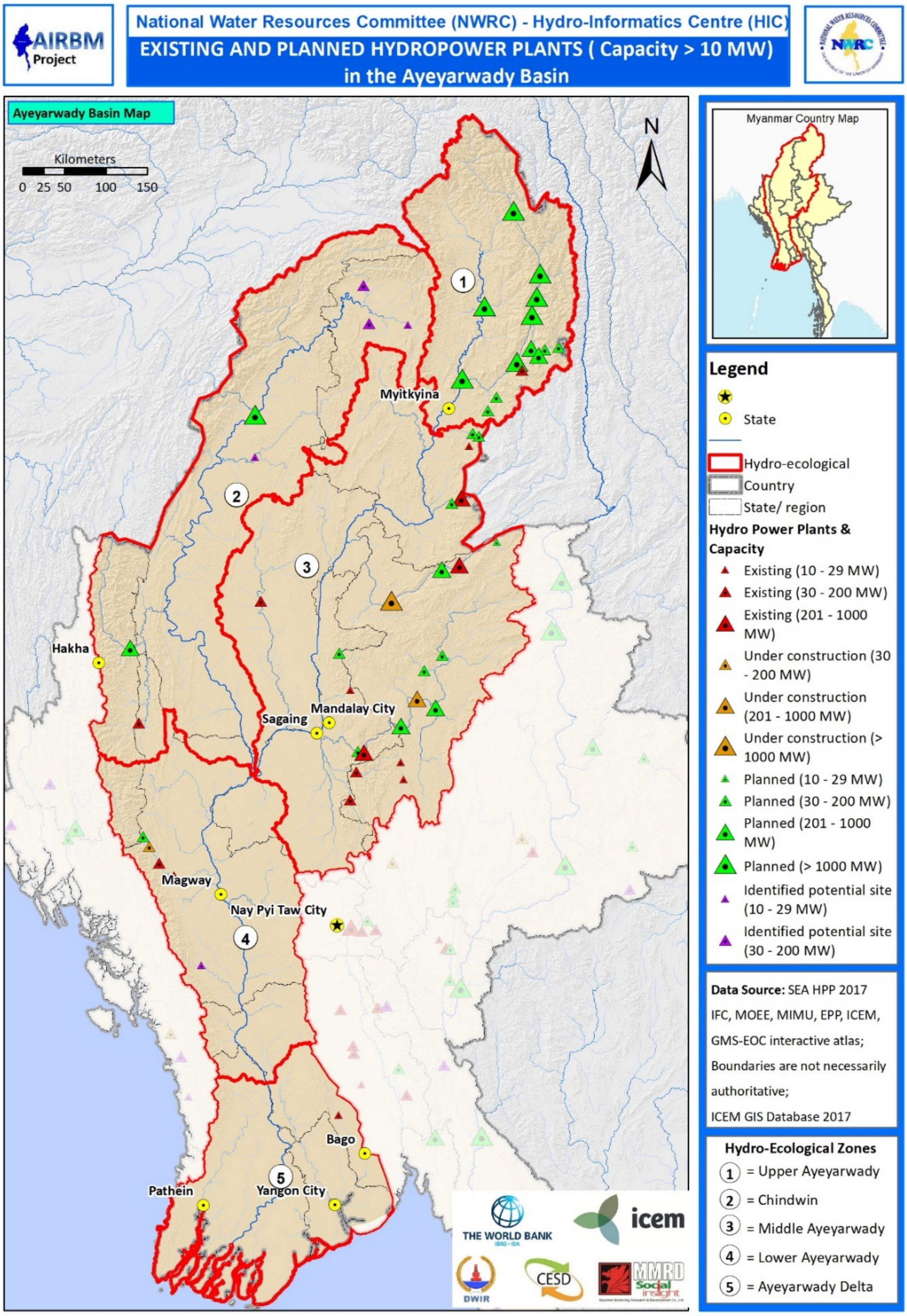


Figure 125 - Existing and planned HP plants (>10 MW) in the Ayeyarwady Basin, 2017

(ICEM, 2017)

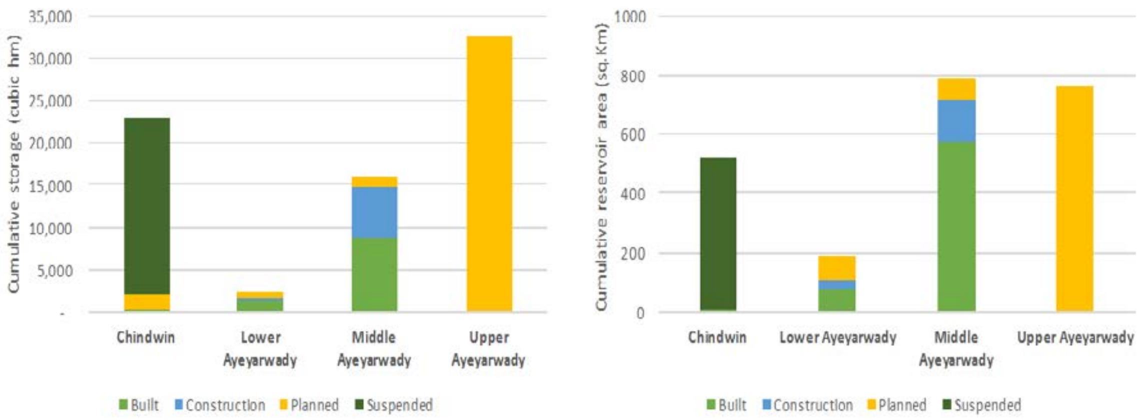


Figure 126 - Current and planned cumulative reservoir storage capacity (a) and cumulative reservoir area (b)

These figures are incomplete. Storage capacity was not available for 12 plants totaling approximately 1,358 MW, including the two existing Zawgyi I and Shweli I plants. Similarly, figures on reservoir size were not available for 17 plants with a cumulative installed capacity of approximately 1,660 MW, including existing plants at Mali and again Zawgyi I. This may be explained by the fact that some of these plants, particularly those of smaller capacity are true run-of-river plants with negligible/no reservoirs. Nevertheless, overall this means these figures will considerably underestimate current and planned storage capacity and reservoir area in the Ayeyarwady Basin (ICEM, 2017)

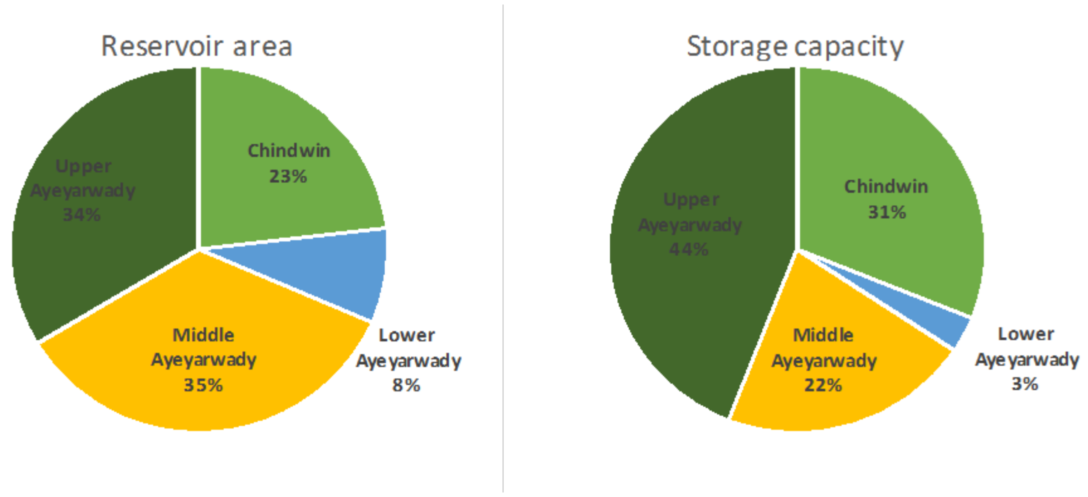


Figure 127 - Reservoir area and reservoir storage capacity by hydro-ecological zone

(ICEM, 2017)

Most of the existing HP plants have been constructed as part of multiple use projects serving both the generation of electricity and water storage for irrigation. In most cases provision of water for irrigation projects has been a priority (see Mu River case study in Section 11). These multi-purpose projects have all been developed and are owned by the government, either under MOALI or the Ministry of Electricity and Energy or a combination of the two ministries. These multiple purpose projects are characterized by a relatively large reservoir area relative to the installed HP capacity, reflecting the priority given to irrigation (Figure 127). This is reflected in the relatively modest scale of installed capacity at multipurpose plants relative to dedicated HP plants and a lower power density. Multiple purpose projects have a much lower power density, with an average of fewer than 2 W/m² relative to over 186 W/m² for dedicated HPPs.[51]

Comparing the profile of existing plants in the Ayeyarwady Basin to those planned, it is clear that the focus of the sector has turned decisively to the development of dedicated HP plants (Figure 128). The three

[51] This figure seems high and may be the result of erroneous reservoir areas included in the HP database.

multiple purpose plants in the pipeline, Buywa (currently under construction), Sedawgyi, and Upper Buywa (both planned), are all being developed by MOALI. This reflects changing development priorities as electricity availability becomes an increasingly important constraint for national development, as well as the ability of the state to fund additional multiple purpose projects (see discussion below).

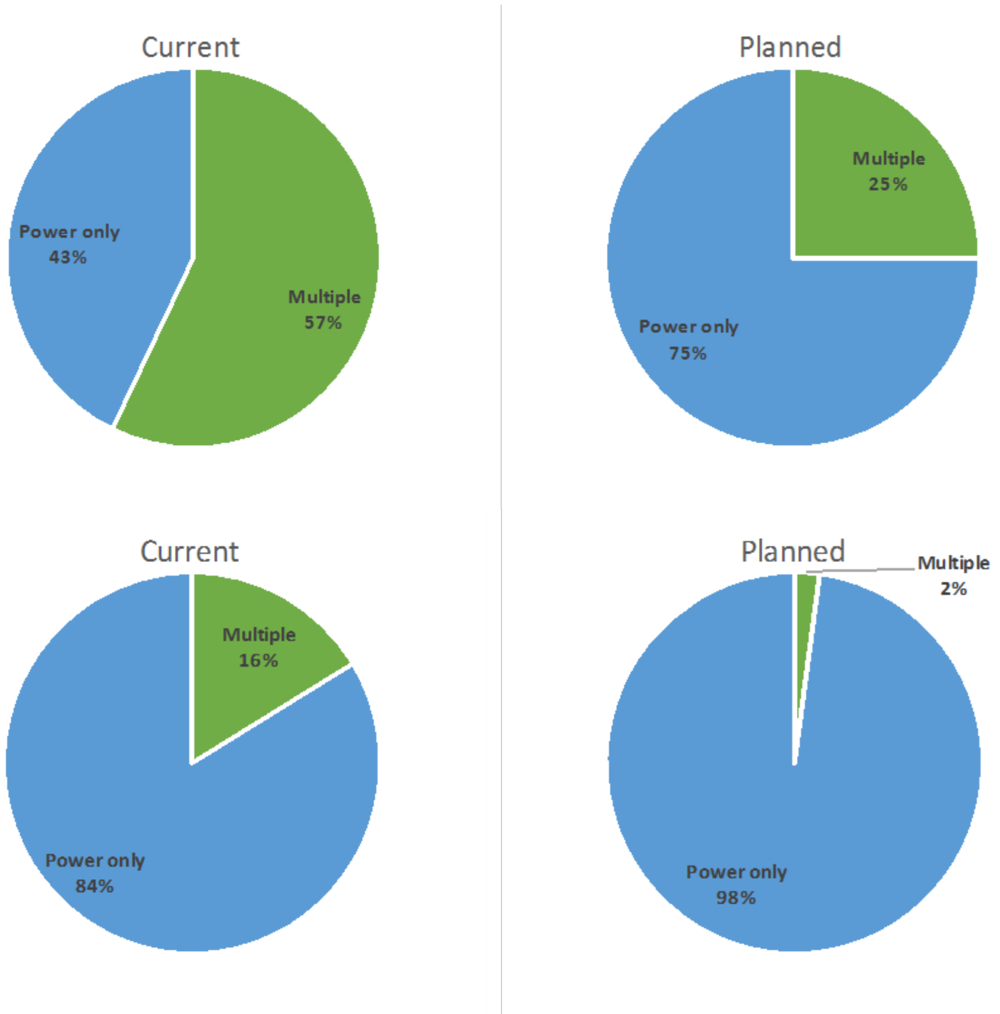


Figure 128 - Power plants for multiple use and power only, by number of plants (%; a) and proportion of installed capacity (b)

(ICEM, 2017)

The project pipeline also reflects the concentration on power generation, as opposed to storage for multiple use, through the growing share of proposed run-of-river (RoR) projects (Figure 129).[52] With the exception of Zawgyi I, all RoR plants are being developed by the private sector.

[52] Whether a project is a run-of-river project or a storage project is determined by the residency time of water in the project reservoir. Projects with residency times of three days or less are defined as RoR projects. However, under some definitions RoR projects may be regarded as those without a reservoir.

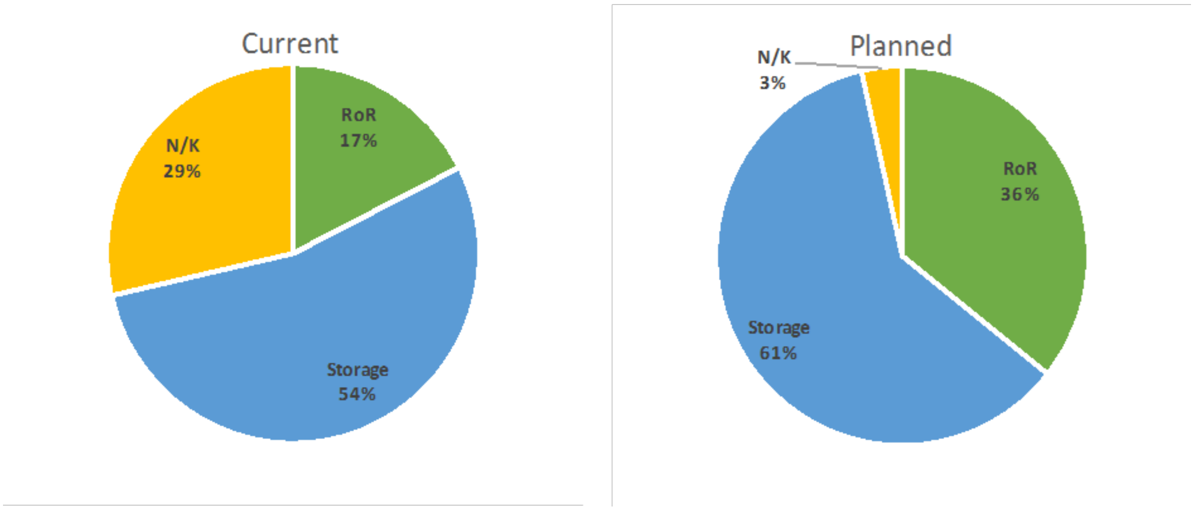


Figure 129 - Proportion of RoR and storage HP plants by installed capacity (%)

(ICEM, 2017)

Private sector investment is of increasing importance to the HP sector. While there has been considerable development of small-scale plants by the domestic private sector, the first plant above 10 MW in size was the 11 MW Mali Plant, which began operations in 2006. The first foreign invested plant in the Ayeyarwady Basin was Shweli 1, which started production in 2009, followed by Dapien 1 in 2011 and Chipwi Nge in 2013, all of which have been invested by the PRC. By 2017 private investment accounted for a little under 46% of installed capacity (Figure 130). By contrast, most of the pipeline projects are foreign invested. If all plants were to be built, this would account for approximately 94% of installed capacity in the Ayeyarwady Basin. There are four public sector funded plants in the development pipeline; two of which are already under construction and three of which are designated for multiple use.

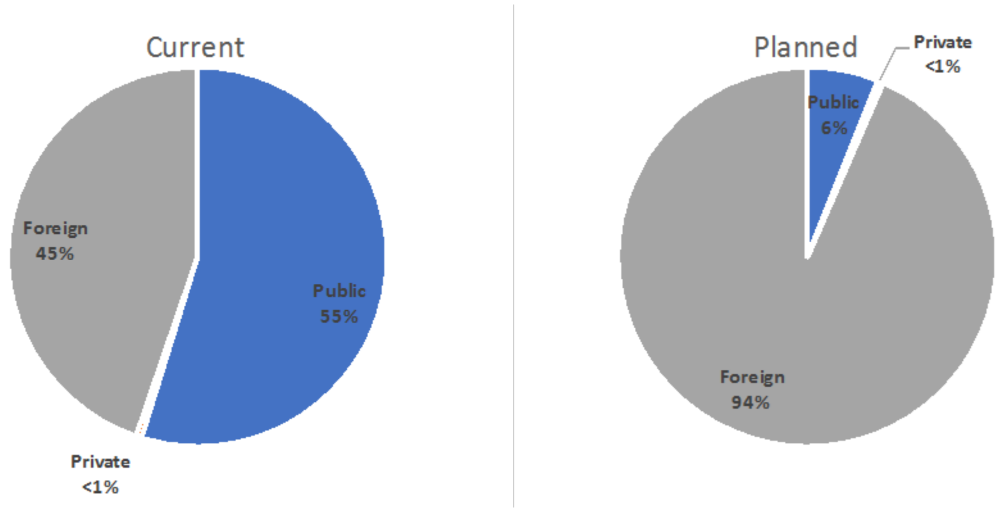


Figure 130 - Source of investment by proportion of installed capacity (%)

(ICEM, 2017)

The advance of FDI in the HP sector is also apparent from the consideration of the investing country. Currently all projects have been funded by either domestic investment or FDI from the PRC, although the sector is still dominated by government investment. Planned projects however show a much broader range of investment partners, including investment from several European countries and India. However, investment from the PRC alone or in collaboration with domestic investors is set to dominate the sector, accounting for over 50% of planned projects both in terms of project number and installed capacity (Figure 131

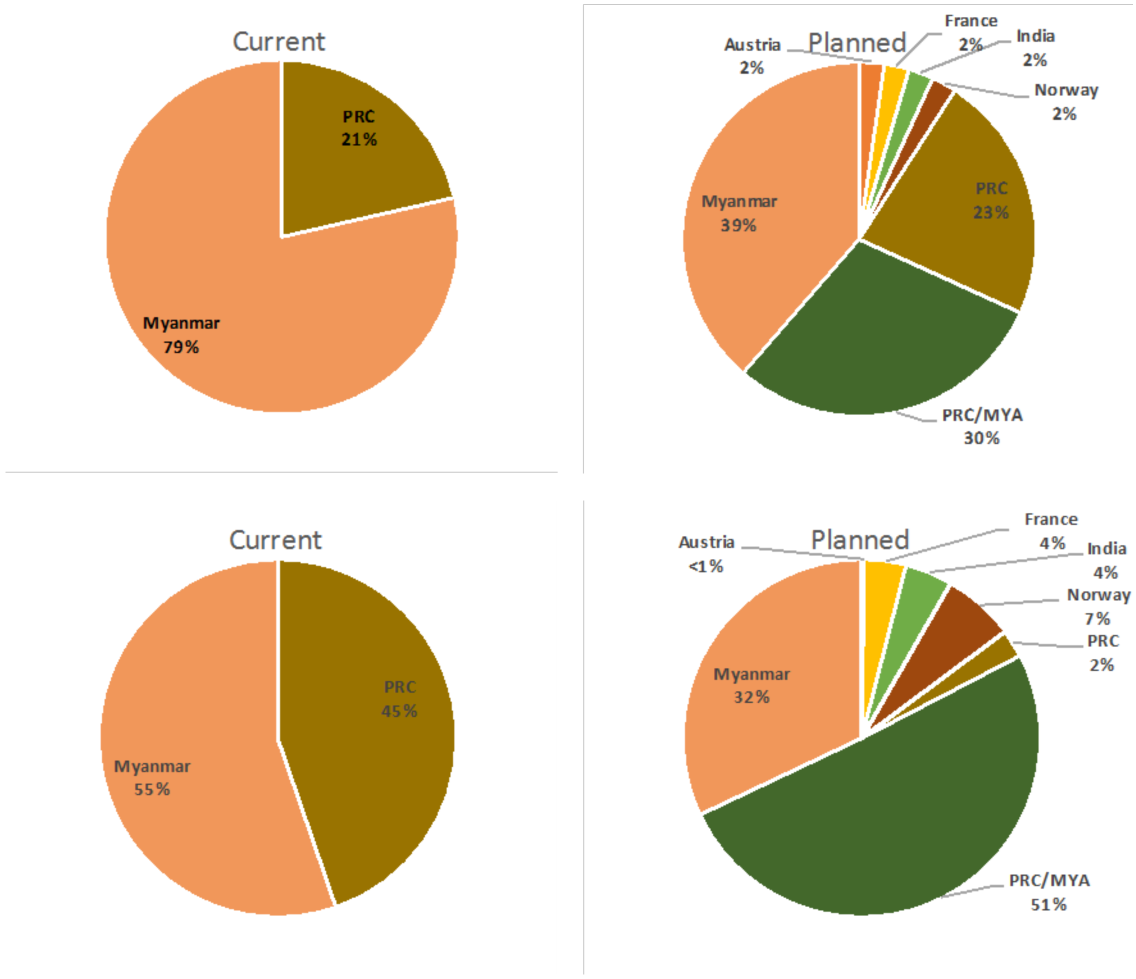


Figure 131 - Proportion of HPPs by investing country, by number of projects (a) and installed capacity (b) *(ICEM, 2017)* ***Note: MYA - Myanmar***

Another important trend in the development of the sector is the growing importance of projects which export some proportion of the power generated. Currently, there are three Chinese invested plants which export to the PRC - Chipwi Nge, Dapein 1, and Sweli 1, with a combined export capacity of 500 MW. If all plants in development were to be built, this would increase to 9.5 GW, although the suspended Myitsone accounts for the lion's share of this. If Myitsone does not progress, the portion of electricity produced for export would actually decline from current levels (Figure 132).

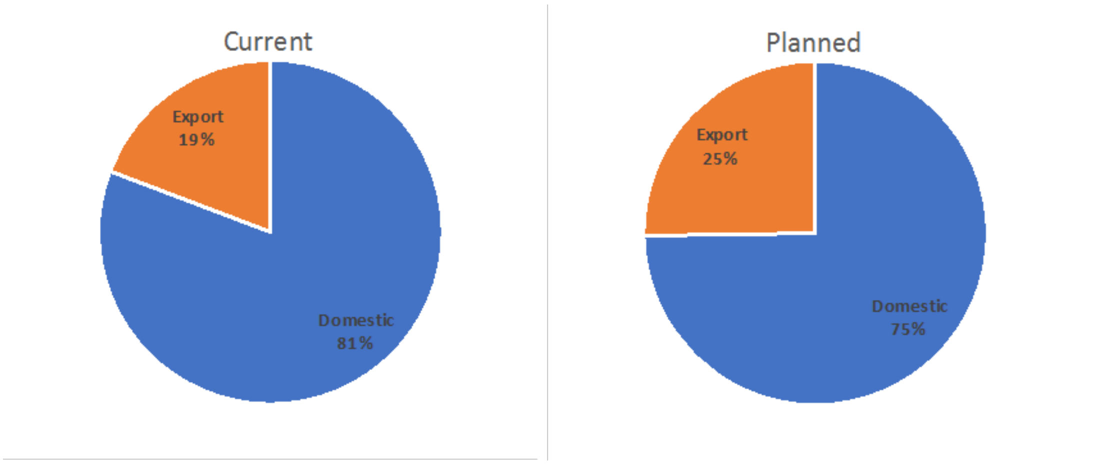


Figure 132 - Power exports from HP plants as proportion of installed capacity current and planned *(ICEM, 2017)*

a) Hydropower in the Upper Ayeyarwady

The Upper Ayeyarwady HEZ represents a catchment size of approximately 47,557 km^2. It includes five rivers in three sub-catchments. Currently, one HP plant has been built and 13 are planned (Table 80).

Table 80 - Hydropower plants in the Upper Ayeyarwady hydro-ecological zone key data

(ICEM, 2017)

Hydropower plant	Capacity (MW)	Generation (GWh)	Reservoir area (km^2)	Reservoir storage (hm^3)	Reservoir length (km)	Retention period (days)	Export (MW)
Existing							
Chipwi Nge	99	599	0.1	1	0.7	0	79
Planned							
Myitsone	6,000	31,290	397.0	13,190	140.0	10	5,400
Laza	1,900	14,720	245.5	11,780	115.0	35	950
Chipwi	3,400	18,200	27.7	1,910	62.0	2	1,700
Khaunglanphu	2,700	14,730	32.9	3,100	85.0	12	-
Pisa	2,000	12,870	7.9	535	31.0	2	-
Renan	1,200	7,330	9.2	1,183	56.0	6	-
Wutsok	1,800	13,410	6.3	605	29.0	1	-
Dum Ban	130	371		34	5.0	9	-
Nam Li	165	473		2	1.0	1	-
Gaw Lan	120	594	6.7	1	3.0	0	60
Hkankawn	140	769	2.0	5	2.8	0	70
Lawngdin	600	2,401	12.4	67	10.7	3	300
Tongxinqiao	340	1,695	8.8	5	4.0	0	170
Total	**20,594**	**119,452**	**756**	**32,418**	**545**	**-**	**8,729**

The only existing plant, Chipwi Nge, is located on the Chipwi Hka in Myitkyina District. Completed in 2013, it has an installed capacity of 99 MW, consisting of a 48 m high concrete gravity dam which serves as an intake to a 10 km headrace tunnel, leading to a powerhouse on the left bank of the N'Mai Hka, gaining a head of 433 m. The plant was constructed to provide power for the construction of Myitsone and Chipwi projects but currently only supplies electricity to Chipwi Village through a 132 kV line to Myitkyina, using only a small proportion of its capacity.

An additional five plants have been proposed by China Power Investment Corporation (SPIC) for development on the N'Mai Hka: Renam, Khaunglanph, Pisa, Wutsok, and Chipwi. If all these projects, and the large Myitsone project were constructed, the N'Mai Hka would be continuously inundated for approximately 363 km, as well as an additional 84 km area inundated upstream of the Chipwi project (Figure 133). Dam heights will vary between 141 - 223 m, resulting in deep reservoirs with large storage volumes with the potential to generate significant water quality issues. These projects are currently scheduled for completion by 2030 (ICEM, 2017).

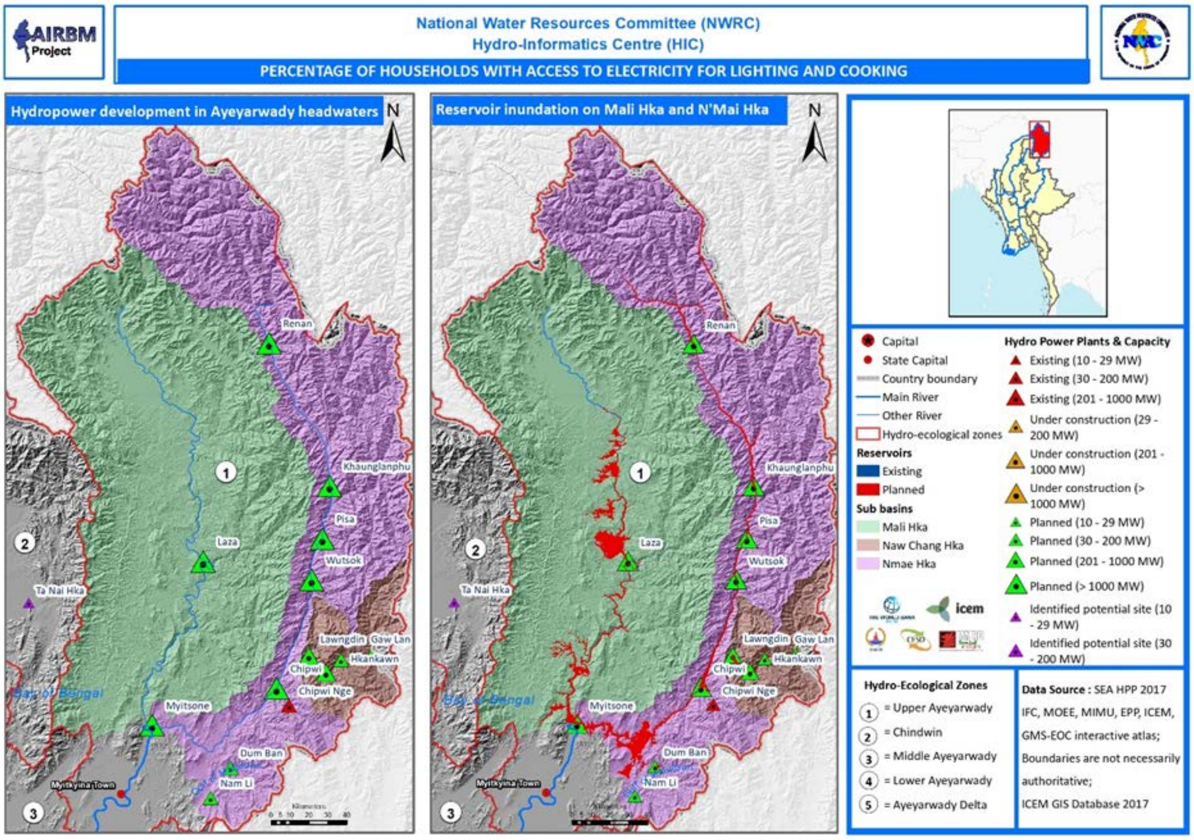


Figure 133 - Hydropower development in Mali Hka, Naw Chang Hka, and Nmae Hka catchments (a) and reservoir inundation on the Mali Hka and N'Mai Hka Rivers (b)

Joining the N'Mai Hka from the east, downstream of Wutsok, the Naw Chang has a cascade of four RoR projects slated for development, by Chinese developer Yunnan Energy Investment Group and International Group of Entrepreneurs Co., Ltd. (Myanmar). These include the Gaw Lan, Hkankawn, Tongxingqiao, and Lawngdin. Further south along the N'Mai Hka, the Nam Li, and Dum Ban projects are on tributaries which join from the south and would drain into the reservoir of the Myitsone project. Nam Li is an RoR project and Dam Ban a small storage project; both projects are being developed by YPEP and Chan Yinn Khuu (ICEM, 2017).

The other major tributary to the Ayeyarwady is the Mali Hka. The 1,900 MW Laza project is the only project planned for this river, again with SPIC as the project proponent. However, it is a large project with a dam height of 196 m, creating a reservoir 115 km long and inundating 245 km^2, with a storage volume of 11,780 hm^3 - almost as large as Myitsone. Fifty percent of the power generated by this plant is slated for export to the PRC.

The final project planned for the Upper Ayeyarwady HEZ is the controversial Myitsone project at the beginning of the mainstream Ayeyarwady where the N'Mai Hka meets the Mali Hka. The project has been suspended since 2011. This very large project would have a reservoir of almost 400 km^2 and a storage volume of over 13,000 hm^3. The project is predominantly aimed at export to the PRC, but 10% of the power (equivalent to approximately 27% of power consumption in 2014 - 2015) would be provided to Myanmar free. The project would benefit from the large upstream storage projects proposed by SPIC on both the N'Mai Hka and Mali Hka. Similarly, the large amount of storage would allow dry season flows in the river to be increased by 16% and reduced by 3.5% during the flooding season.

Combined, the existing and proposed projects in the Upper Ayeyarwady would have significant impacts. They would represent approximately 20.6 GW of installed capacity (over four times the total national capacity in 2014 - 2015), generating over 199 TWh of electricity annually (over 70 times of that generated in 2013 - 2014). At the same time this would imply the inundation of 645 km of rivers and 760 km^2 of land area, along with a total storage amount of almost 33,400 hm^3 and 44 km of rivers run dry or left with much reduced flows, depending on the environmental management regime adopted.

b) Hydropower in the Chindwin

Currently there is one HP plant in the Chindwin HEZ and a further six proposed. Of these, four (U Yu Chaung, Ta Rung Hka, Ta Nai Hka, and Tawog Hka) are at a very early stage of development with little substantive information available. The large Htamanthi project has been suspended. Table 81 summarizes available information on the Chindwin projects.

Table 81 - Hydropower plants in the Chindwin hydro-ecological zone key data

(ICEM, 2017)

Hydropower plant	Capacity (MW)	Generation (GWh)	Reservoir area (km^2)	Reservoir storage (hm^3)	Reservoir length (km)	Retention period (days)	Export (MW)
Existing							
Myittha	40	170	12.2	325	-	45	-
Planned							
Manipur	380	1,903	-	1,643	45.0	52	-
U Yu Chaung	12.0	-	-	-	-	-	-
Ta Rung Hka	150.0	-	-	-	-	-	-
Ta Nai Hka	15.0	-	-	-	-	-	-
Tawog Hka	50.0	-	-	-	-	-	-
Suspended							
Tamanthi	1,200	6,685	509.0	20,922	-	47	-
Total	**1,847**	**8,758**	**521**	**22,890**	**45**	**-**	**-**

The only existing large plant in the Chindwin basin is on the Myittha River in the Gangaw District of Magway Region, completed in 2017. The 40 MW plant is a multiple-use project constructed by MOALI. As with other multiple-use projects, this one has a relatively large reservoir storage volume of 325 hm^3 and reservoir area of 12 km^2 relative to its installed capacity.

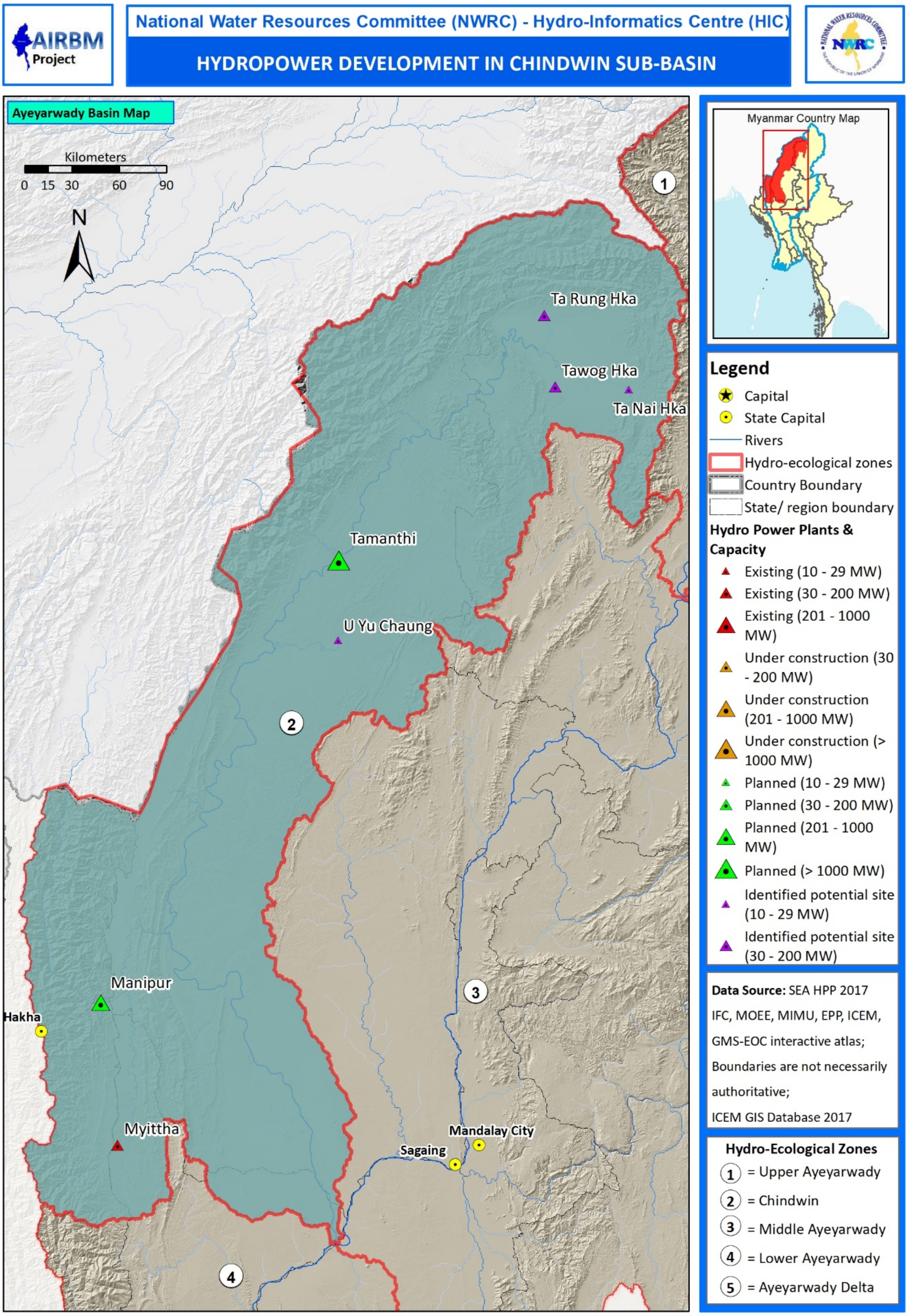


Figure 134 - Existing and planned HP development in the Chindwin Basin

The two planned projects in the HEZ are relatively large by comparison. The 1,200 MW Htamanthi project is located on the Chindwin at Hkamti. The project, with a dam of 74 m would create a large reservoir with considerably greater storage (almost 21,000 hm^3) and inundation area (509 km^2) than Myitsone. As such it has the potential to significantly reduce flooding on the Chindwin and Ayeyarwady. However, the river has a high sediment load and the project is located in a seismically active area with potentially large social impacts affecting 50 villages and two towns. As such, the project was suspended prior to a Memorandum of Understanding being agreed. The second is a 380 MW project on the Manipur River, a tributary to the Myittha. The project is designed to have a high dam of 168 m and a reservoir storage of over 1,500 hm^3. A Memorandum of Understanding for the project has been completed and feasibility study submitted to MOEE.

c) Hydropower in the Middle Ayeyarwady

There are currently ten HP plants with an installed capacity of 1,812 MW in the Middle Ayeyarwady HEZ, with reservoirs cumulatively inundating 590 km^2, running along 179 km of rivers, and storing approximately 8,800 hm^3 of water. A further two projects are under construction adding another 1,330 MW in capacity, 70 km^2 in inundated area, and 5,769 hm^3 in storage. Most of the projects are for dedicated HP production but four are for multiple use. The development pipeline includes a further 11 projects with a total installed capacity of 2,146 MW (Table 82).

Table 82 - Hydropower plants in the Middle Ayeyarwady hydro-ecological zone key data

(ICEM, 2017)

Hydropower plant	Capacity (MW)	Generation (GWh)	Reservoir area (km^2)	Reservoir storage (hm^3)	Reservoir length (km)	Retention period (days)	Export (MW)
Existing							
Dapein 1	240	1,065	0.4	22	3.6	1	221
Sedawgyi	25	134	40.5	448	16.1	30	-
Mali	11	54	-	-	-	-	-
Thapanzeik	30	117	397.1	3,552	42.8	170	-
Yeywa	790	3,550	59.0	2,630	75.0	39	-
Kinda	56	165	28.6	1,078	14.5	290	-
Myogyi	30	136	9.7	443	10.7	45	-
Zawgyi I	18	35	-	-	-	-	-
Zawgyi II	12	30	38.5	639	8.2	139	-
Shweli 1	600	4,022	1.1		10.5		200
Under Construction							
Upper Yeywa	280	1,409	26.9	341	54.0	6	-
Shweli 3	1,050	3,400	118.0	5,464	65.0	92	-
Planned							
Dapein 2	140	642	-	55	8.0	1	70
Upper Sedawgyi	64		24.0	593		55	-
Deedoke	66	338	-	13	19.0	-	-
Middle Yeywa	700	3,253	11.0	454	70.0	6	-
Nam Hsim	30	-	-	-	-	-	-
Nam Lang	210	-	-	-	-	-	-
Nam Tu	100	635	-	-	4.0	-	-
Nam Tabak I	141	684	2.2	15	0.6	0	-

Hydropower plant	Capacity (MW)	Generation (GWh)	Reservoir area (km²)	Reservoir storage (hm³)	Reservoir length (km)	Retention period (days)	Export (MW)
Nam Tabak II	144	635	-	-	2.6	-	-
Nam Paw	20	83	-	52	1.3	11	-
Shweli 2	520	2,814	27.9	72	20.0	1	260
Total	5,277	23,200	785	15,871	426	-	751

Most of the major tributaries to the Ayeyarwady in the Middle Ayeyarwady HEZ have some HP development on them. In particular, tributaries rising in the PRC or with a significant catchment area in the PRC are highly developed. The area of the Namtabak catchment in the PRC already has 19 RoR and storage projects completed, and that of the Dapien 18 projects.

Existing development in Myanmar is more modest. Moving from north to south down the Ayeyarwady, the first tributary with HP development past the Mali Hka-N'Mai Hka confluence is the Mali River. This has one relatively small 10.5 MW project which was completed in 2006, and it is the only plant above 10 MW that has been built by the domestic private sector, in this case on a build, operate, transfer basis (Figure 135). It provides power to Myitkyina and the surrounding area. Next is the Dapien River, where the 240 MW RoR Dapien I plant was completed in 2011. The plant was developed by China Datang Corporation and most of the power is exported via a 500 kV transmission line to the PRC, with 19 MW being provided to the Myanmar grid via a 132 kV line to Bahmo (Figure 135).

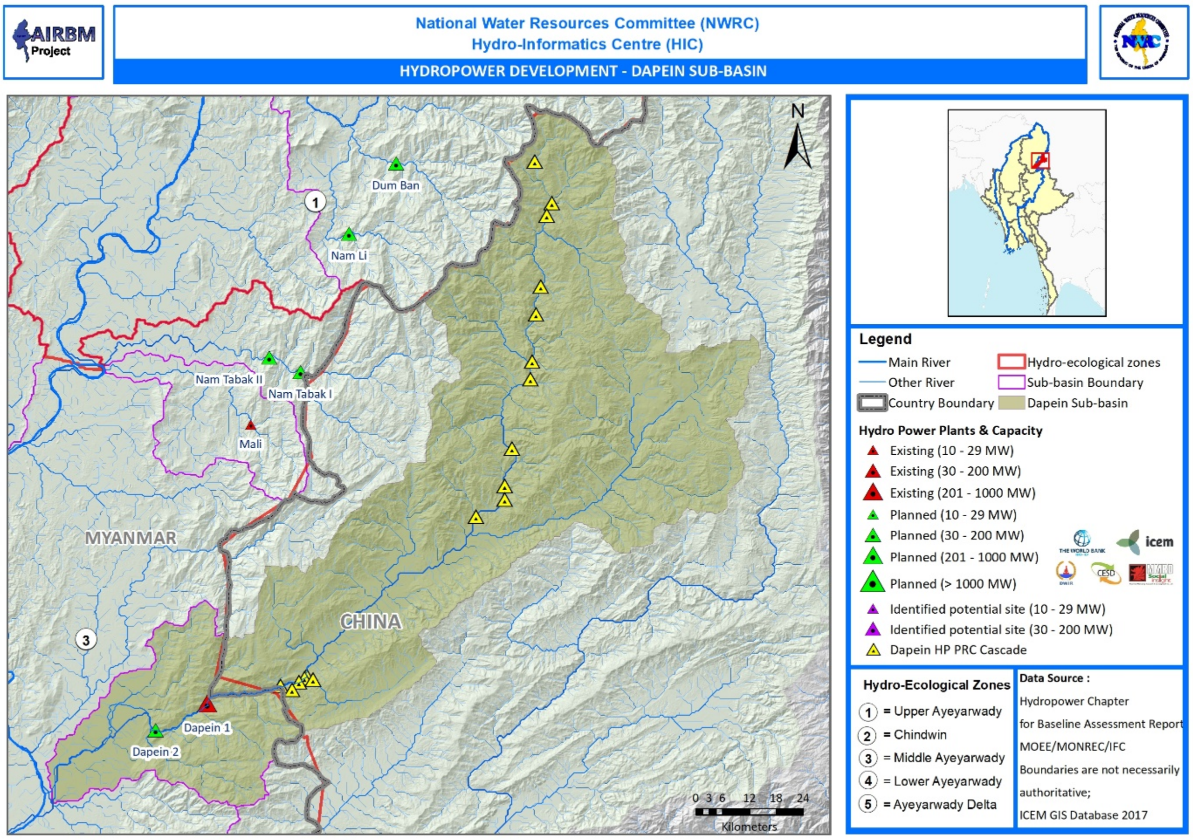


Figure 135 - Hydropower plants on the Dapien

There are currently two HP plants on the Shweli River (Figure 136). Shweli I is a 600 MW plant completed in 2009, developed by Yunnan Joint Power Development Co., which mainly serves the Myanmar grid but one-third of its capacity is exported to the PRC. The second plant on the river is Shweli 3, which is currently under construction. Shweli 3 is a relatively large project with an expected capacity of 1,050 MW and a 150 m high dam creating a reservoir area of 43 km² with a storage capacity of 5,427 hm³. Currently the project has been suspended due to lack of funds, although MOEE is in negotiations with Electricité du France to take over the project. Sedawgyi is a 25 MW plant on the Ma Gyi Chaung River in the Mandalay Region. It is a multi-purpose project with the water diverted approximately 4 km downstream of the turbines by an irrigation weir. The project was built and is being operated by MOALI.

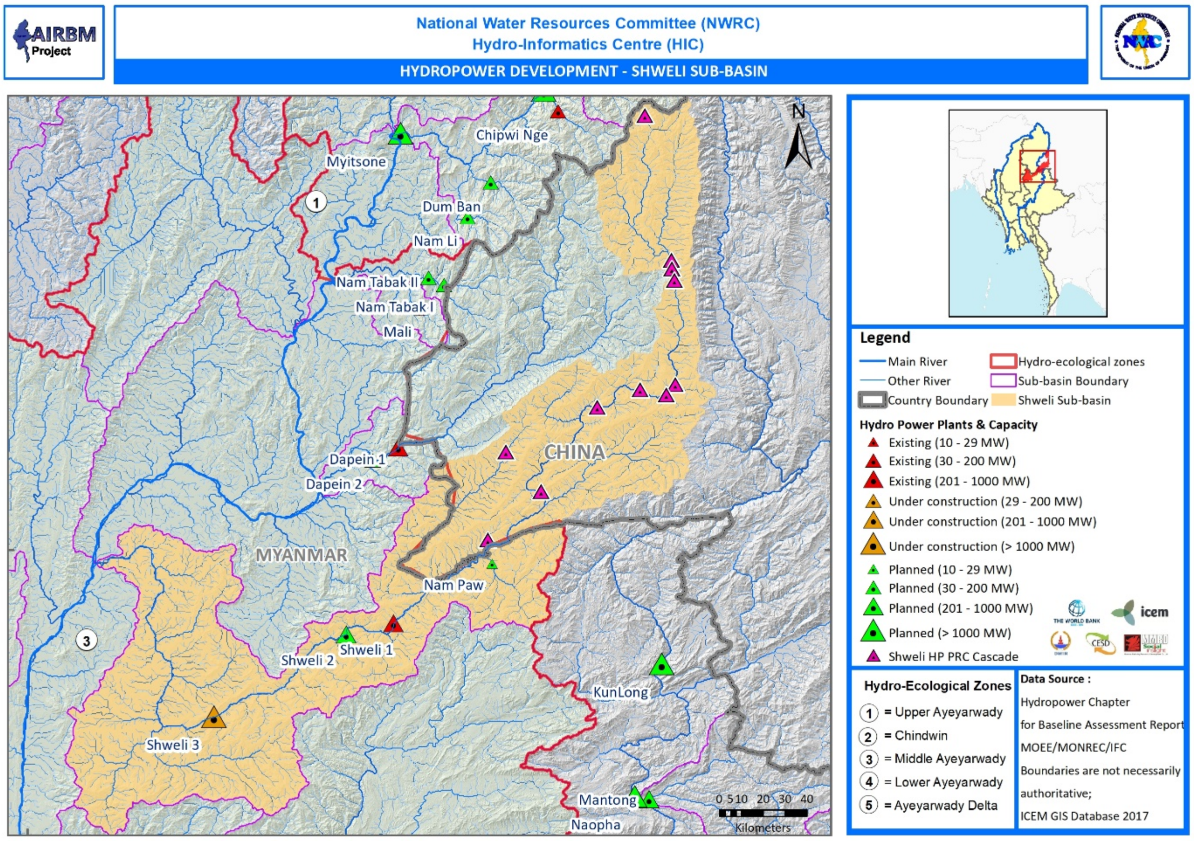


Figure 136 - Hydropower development on the Shweli

The Myitnge River is home to the Yeywa and Upper Yeywa projects. Currently, the Yeywa HP plant completed in 2010 is the largest in Myanmar at 790 MW. It has a dam of 132 m creating a 75 km reservoir covering an area of 59 km², with a storage of 2,607 hm³. The MOEE developed dam supplies power to the national grid via substations in Belin and Meiktila. The Upper Yeywa project is currently under construction. Expected installed capacity is to be 280 MW, with a 97 m dam creating a reservoir 60 km long, with a surface area of 26.9 km² and storage of 342 hm³. The project will inundate two villages and has been the subject of some protests. Currently the project is 28% complete.

There are three smaller projects on the Zawgyi River in Taunggyi District: the 18 MW RoR Zawgyi I, the 12 MW Zawgyi II, and 30 MW multipurpose Myogyi plant owned by MOALI. The 56 MW Kinda project on the Panlaung Chaung was completed in 1985 is also a multipurpose project. Finally, the 30 MW Thapenzeik project is another MOALI owned multipurpose plant on the Mu River (see Mu River case in chapter 12). This project is primarily managed to serve irrigation needs and has the largest reservoir in the country at 397 km² and 49 km long along the main branch of the Mu River.

The first of the 11 pipeline projects in the Middle Ayeyarwady are those on the Nam Tabak River - the 141 MW Nam Tabak I and the 144 MW Nam Tabak II (Figure 137). The projects are scheduled for completion by 2027. There is one additional plant currently planned for development in the Dapien catchment, the 140 MW Dapien 2. This is a RoR project with a dam of 59 m and a relatively small reservoir.

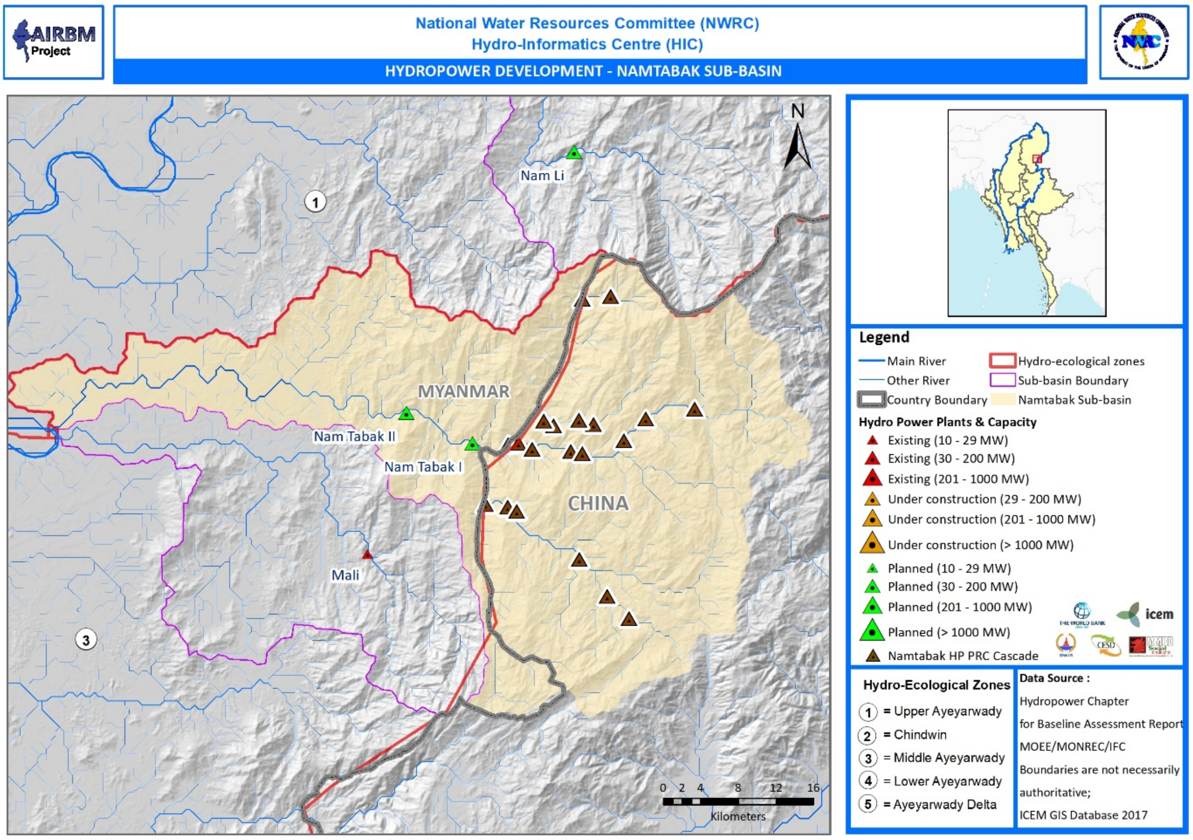


Figure 137 - Hydropower development on the Nam Tabak

In the Shweli catchment there are an additional two plants in development: the 520 MW Shweli 2 and the 20 MW Nam Paw. Shweli 2 is being developed by Yunnan Joint Power Development Co. and Asia World Company (Myanmar), with 50% of the power being exported to the PRC. Progress on the plant has been slow since the submission of an Environmental Impact Assessment to the Ministry of Natural Resources and Environmental Conservation (MONREC) in 2013, possibly due to local opposition. It is unlikely that it will be completed by the 2021 completion date. Nam Paw is being developed by the Great Hor Kham company, publicly listed in Myanmar. Construction is scheduled to start in late 2017 and be completed by 2019.

The Upper Sedawgyi is a MOALI sponsored multipurpose project. It is located 13 km upstream of the Sedawgyi Dam. The dam height is 73 m and expected capacity is 64 MW. The reservoir created will cover an area of 24 km^2 and store 593 hm^3. It is not clear when this project will commence.

There are an additional five HPPs being developed in the Myitnge catchment - two on the Myitnge River and three upstream from Upper Yeywa. Middle Yeywa is a 700 MW project with a 160 m high dam creating a 70 km long reservoir, a 11 km^2 inundation area and 454 hm^3 of storage. A feasibility study is currently underway for the plant and its scheduled completion date of 2021 looks unlikely to be met. Deedoke is being developed by Andritz Hydro (Austria). It is a RoR project with a 27 m high dam, and 77 MW of installed capacity. The plant would take advantage of regulation offered by the Yeywa reservoir. The Nam Tu project is located in the upper Myitnge catchment. It is a 100 MW project with a dam height of 114 m. Its scheduled completion date of 2020 currently looks unrealistic. A further two plants are proposed for the Myitnge - the 30 MW Nam Hsim and the 160 MW Nam Lang (Figure 138). No further details on these plants is available.

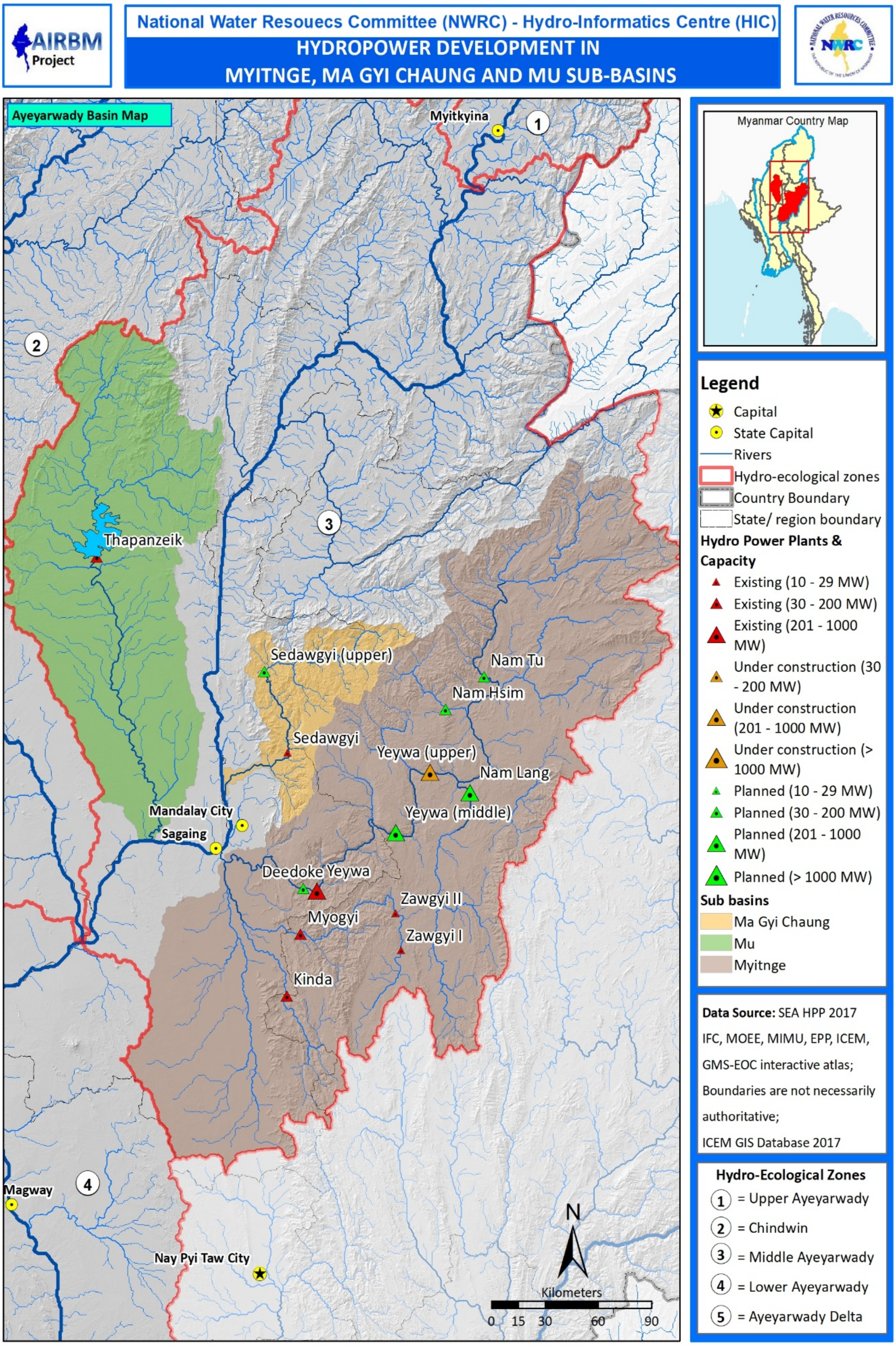


Figure 138 - Hydropower development in Myithnge, Ma Gyi, and Mu sub-basins

d) Hydropower in the Lower Ayeyarwady

Existing and planned HPPs in the Lower Ayeyarwady HEZ are more limited. Currently, there is a total of 359 MW of capacity existing or otherwise under development. This includes two existing projects, one under construction and a further two plants in development (Table 83 and Figure 139).

The two existing plants are situated on the Mone Chaung River, a tributary to the Ayeyarwady which joins the river from the southwest of the confluence with the Chindwin. The Mone Chaung project is a multipurpose project with 75 MW of installed capacity and a 61 m high rock-fill dam with a 42 km^2 reservoir that stores 832 hm^3. The project was completed in 2002. The 74 MW Kyeeon Kyeewa project, completed in 2012, has a 50 m dam creating a 33 km^2 reservoir with storage capacity of 571 hm^3. This is also a multipurpose project. Additionally, the 42 MW multipurpose Buywa plant will utilize a 46 m dam creating a reservoir of 38 km^2 in area, storing 209 hm^3. All three projects are owned and operated by MOALI.

Table 83 - Hydropower plants in the Lower Ayeyarwady hydro-ecological zone key data

(ICEM, 2017)

Hydropower Plant	Capacity (MW)	Generation (GWh)	Reservoir area (km^2)	Reservoir storage (hm^3)	Reservoir length (km)	Retention period (days)	Export (MW)
Existing							
Kyee Ohn Kyee Wa	74	370	32.8	571	29.8	52	-
Mone Chaung	75	330	41.5	832	19.4	76	-
Under construction							
Buywa	42	-	38.1	209	-	-	-
Planned							
Mindon	18.0	-	-	-	-	-	-
Upper Buywa	150	534	76.2	721	-	17	-
Total	359	1,234	189	2,333	49	-	-

Two additional multipurpose projects are in the pipeline, both of which are being developed by MOALI. The first, the Upper Buywa project, is expected to have an installed capacity of 150 MW, utilizing a 138 m dam, with a reservoir surface area of 76 km^2 and 721 hm^3 of storage. The second, Mindon, is expected to have 18 MW of installed capacity. Currently more details are not available.

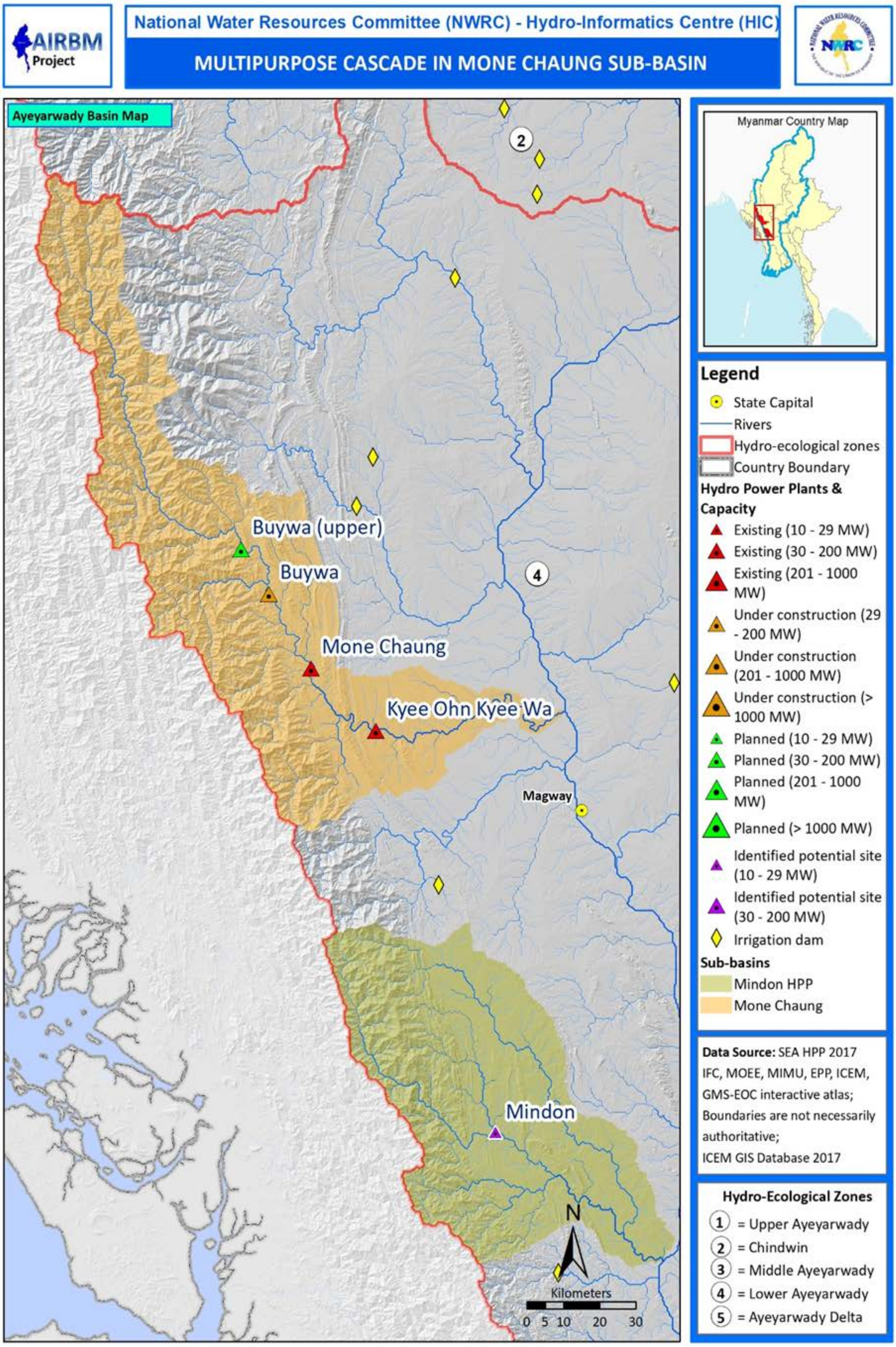


Figure 139 - Hydropower development in the Lower Ayeyarwady Basin

e) Drivers of HP development in the Ayeyarwady Basin

Hydropower has accounted for most capacity additions over the last decade. This is due to the availability of good HP resources, the relatively low cost of HP and probably the availability of (mainly Chinese) developers with the technical and financial wherewithal to pursue the projects. The preference for HP is also due to the limited domestic coal resources, which are generally of low quality. Myanmar's significant gas reserves have been developed by foreign companies and most current gas production is subject to long-term supply agreements with Thailand and China. Thus far renewables have made little headway beyond the provision of off-grid electricity.

8.4.3 Key issues for the HP sector

Hydropower development in the Ayeyarwady Basin offers the opportunity to develop relatively cheap, clean domestic energy resources, meeting projected demand for electricity generation and enabling the continued development of higher value-added industries in manufacturing and services. Hydropower development also offers the possibility of the generation of revenue for local and national governments. The extent of these revenues will typically depend on national and sub-national policy, but also upon the individual PPAs agreed for HPPs. There also remains a broader governance question as to the effective use of such revenue streams which needs to be considered.[53]

On the other hand, HP plants are often controversial due to their wide-ranging social and environmental impacts. While it is beyond the remit of this study to investigate these potential impacts in any detail, it is worth considering the range of potential impacts, of which the most important are:

- **Hydrology and geomorphology** - Hydropower plants can significantly alter the hydrology and geomorphology of a river system. The most important impacts include changes in flow regime and sediment load. Changes in flow can have important implications for erosion, biodiversity, fisheries, community well-being, navigation, and riverine agriculture. The reduction in sediment loads can pose issues in terms of downstream erosion and river morphology, nutrient transport, and deltaic stability.
- **Biodiversity** - Hydropower can be severely detrimental to aquatic and terrestrial biodiversity. Often plants are constructed in upland areas which have substantially intact ecosystems. The HP plants directly disrupt these systems (through loss of forest cover in inundation area, barriers to fish migration, loss of aquatic habitat, changes in water temperature, and declines in water quality). In some cases impacts such as road and power line construction can be equally harmful to terrestrial ecosystems through enabling human access to previously inaccessible areas and fragmenting habitats.
- **Fisheries** - Hydropower plants present a barrier to fish migration (often an essential part of lifecycles), result in the loss of aquatic habitat (either through downstream dewatering, upstream impoundment creation, or through other impacts related to changes in flow and sedimentation, and through deleterious impacts on water quality).
- **Land** - Hydropower plants often occupy large areas of land, most obviously in the reservoir inundation areas. In upland areas where suitable agricultural land is in short supply this can prove problematic. Weak land tenure arrangements can leave communities vulnerable to land expropriation and inadequate compensation. Riverbank gardens and other riverine structures used for agricultural production may also be lost or rendered unusable in some circumstance.
- **Involuntary resettlement** - Communities often have to be resettled to make way for HP plants, again often in the inundation area. Resettling communities can prove problematic, viable agricultural land is often in short supply in upland areas, and communities often have economic, social, and cultural ties to the areas within which they live. Reestablishing communities in new areas can imply a long-term support. This presupposes the capacity, financial wherewithal, and political will to ensure such support is provided, which is often not the case.
- **Broader social impacts** - Aside from communities directly displaced by HPPs, communities living in a broader zone of influence of HP plants may be affected by their development. Communities downstream of plants may be affected by changes in flow regime (much reduced flows, unseasonal

[53] This is beyond the remit of this study, for further discussion see NRGI (2016) and Adam Smith International (2014).

flows, etc.). This can affect access to land for purposes such as riverbank gardens, and affect soil fertility though the disruption of nutrient transport. Similarly, any reduction in the availability of natural resources important to livelihoods (like NTFPs and fisheries) can have serious impacts on rural communities.

- **Construction impacts** - During the construction period, declines in water quality due to construction activities and the influx of a large number of workers can have serious impacts on local communities and biodiversity.

It should also be noted that the potential regulation of a river system by large HP plants can offer potentially significant benefits. This includes the provision of water storage for use in irrigation schemes (as noted, there are already many multiple-use schemes in the Ayeyarwady Basin), reduction in floods during the wet season, and increases in dry season flows. The increase in dry season flows may offer some benefit to agricultural production, particularly in the Delta through the reduction of saline intrusion. Moreover, measures taken to enhance HPPs, such as the creation of watershed protection forests, can actually serve to enhance ecological outcomes in some circumstances.

8.5 Conclusions

8.5.1 Key findings

The Ayeyarwady Basin is home to considerable energy resources including oil, gas, coal, HP, and other renewable potential. Many of these resources remain unexploited. While the largest fossil fuel basins have been fully explored, there remains a degree of uncertainty regarding remaining fossil fuel potential in the Ayeyarwady Basin. Oil and gas extraction in the Ayeyarwady Basin serves domestic markets, and most of Myanmar's onshore oil and gas infrastructure is located in the Ayeyarwady Basin. This includes the country's three main oil refineries (as well as numerous unofficial artisanal operations), as well as oil and gas pipelines linked to major population centres in the Delta and Lower Ayeyarwady HEZs. Production has declined in recent years, and the resources in the basin have declined in importance relative to the development of much larger off-shore fields. The Ayeyarwady Basin is also cross-cut by the Shwe oil and gas pipeline which takes off-shore gas and transshipped oil from the Bay of Bengal to Kumming, in Yunnan in the PRC.

The Ayeyarwady Basin also has some significant coal reserves; the most important of which are in the Chindwin HEZ and in particular the mine at Kalewa, which in the future will serve a 600 MW coal plant currently under construction. According to available production figures, coal mining in the Ayeyarwady Basin is also in decline although the reasons for this are not clear. The Ayeyarwady Basin also has significant solar, wind, and biomass potential, although most of this has yet to be developed. It should be said that the unsustainable use of biomass accounts for the lion's share of energy use in the Ayeyarwady Basin.

Household energy use in the Ayeyarwady Basin accounts for 60 - 70% of total energy use and is a critical factor in determining the sustainability of development in the basin. The high level of energy consumption is largely due to a reliance on biomass, and fuelwood and charcoal in particular as the main energy sources used for cooking and water heating. These resources are typically used inefficiently in traditional stoves, which waste much of the energy generated. This unsustainable use of fuelwood is probably an important contributory factor to forest degradation and deforestation. This is compounded by the relatively recent development of a significant cross-border trade in charcoal (and to a lesser extent, fuelwood).

The lack of household electrification is an important contributory factor to this household energy use dynamic. Very low levels of electricity access in the basin and reliance on expensive off-grid and mini-grid alternatives (solar home-systems, diesel generators, kerosene lamps, etc.) are an important rural development issue. Lack of electricity access also stymies local economic development.

Turning to the power sector, the lack of adequate electricity provision remains a critical issue for the basin and the country. Most of the country's generation assets are located in the Ayeyarwady Basin. Currently, these consist of gas turbines located round Yangon and other major population centres and HP, although as noted one coal plant is currently being constructed in the Chindwin Basin.

The Ayeyarwady Basin is home to a considerable amount of HP with 14 large plants currently in operation (approximately 2.1 GW of installed capacity), a further three under construction (1.37 GW) and 29 planned (25.6 GW). Most of these are planned for the mountainous Upper Ayeyarwady and Middle Ayeyarwady HEZ, with fewer plants in the Chindwin and Lower Ayeyarwady, and none in the flat deltaic areas. Most HP plants built to date have been funded by the public sector, and built for both HP and irrigation purposes. These have relatively limited installed capacity and generally provide power for domestic consumption. However, beginning in the 2000s this changed as large dedicated HP plants were built more frequently, predominantly Chinese owned or often funded with a share of power production for export to the PRC. This trend is set to continue with mostly foreign owned and funded plants for HP production in the development pipeline.

While there is undoubtedly a pressing need for the electricity HP could offer, the impact on the basin could be substantial if all these plants are implemented. Significant changes in flow regime and sediment load will alter many bio-physical processes in the basin. Many communities in upland areas will be displaced and natural systems (particularly aquatic systems) disrupted, affecting their diversity and productivity.

9 TRANSPORT

9.1 Outline of Transport Economic Analyses

9.1.1 *The Overarching Issues*

a) Long-term underinvestment

Perhaps more than any specific issue with IWT, or indeed the sum of all issues specific to IWT, the key issue facing transport in Myanmar, in general, is that there have been decades of underinvestment, which has affected all modes. As a consequence, there has been a degradation of pre-existing networks and a reduction in capacities and operating speeds to the point where, as shall be discussed, railways are operating largely at capacity (at least for northbound freight trains), road pavement conditions are often sub-optimal, and IWT volumes have declined.

b) Economic reorganisation and its impacts on IWT

Economic consequences have followed from the relatively recent political changes in Myanmar. These include a liberalisation of regulations on the import of second-hand vehicles into Myanmar, which has resulted in substantial growth in the vehicle fleet, and hence, additional competition to IWT methods. However, another change, which would appear to have had a material impact upon IWT, is increased environmental protections and oversights that have led to significantly reduced demand for the transport of cargoes related to the mining and logging industries in particular.

c) IWT's potential to achieve cost and environmental efficiencies

While caution should always be advised when applying cost structures from one country to another, one of the key themes underscoring the SOBA programme is that IWT has the potential to be more financially, economically, and environmentally efficient than other modes. This can be illustrated using data from the USA, as presented in Figure 140.

It should, however, be noted that the metrics in Figure 138 are not only based on USA data but also assumed full containerisation, whereas IWT in Myanmar is not generally containerised. Indeed, there are currently no facilities for containerisation north of the Twante Canal. It also presupposes high capacity ulitisation, something which is not currently being achieved by ships in the Ayeyarwady Basin.

All the same, Figure 140 could be taken as indication of the potential for IWT.

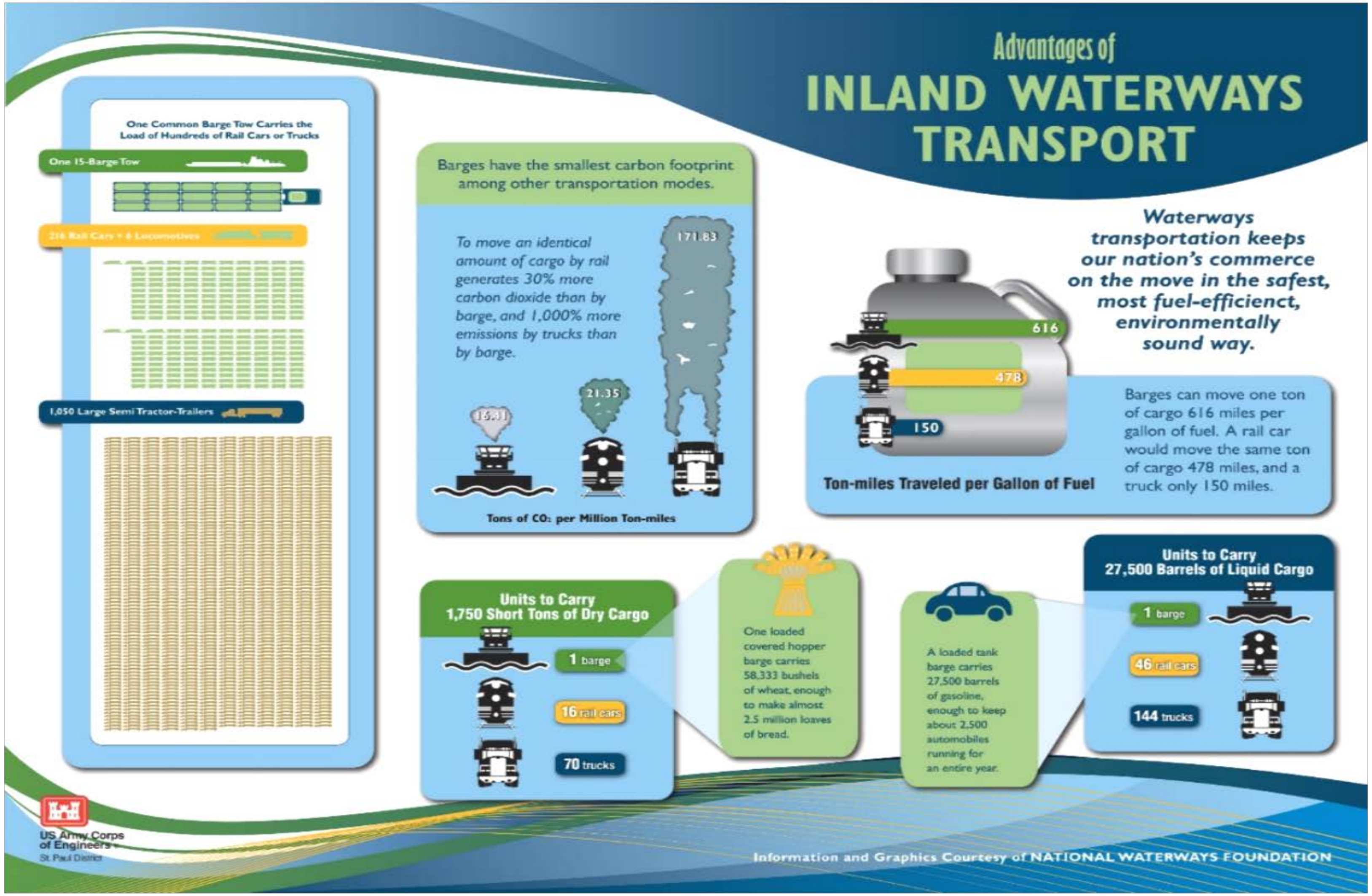


Figure 140- Cost and carbon comparison between modes, based on USA data

(US Army Corps of Engineers)

9.1.2 *Purpose and Broad Approach*

In light of the above overarching issues, the purpose of the economic analysis under this project is to provide an overview of baseline economic conditions in the Ayeyarwady Basin. It is hoped that such an approach will assist in identifying priorities for interventions by flagging opportunities and risks alike. However, it should be noted that robust quantification of the likely benefits of various interventions being mooted is beyond the scope of this baseline assessment. Nevertheless, some indicative assessment of potential benefits of such interventions will be provided as appropriate.

The transport economic analyses described herein were based on a number of data sources, namely, secondary data obtained from the Government of Myanmar, such as IWT tariffs collected from vessel operators, as presented in Section 9.2.6; other secondary data obtained from previous consultancy and development agency reports; interviews with public sector (Government of Myanmar) and private sector (domestic and international) stakeholders;[54] discussions with other concerned parties working on Ayeyarwady Basin initiatives; observations made during site visits, including when travelling the Mandalay to Nyaung-U stretch of the Ayeyarwady River; and a literature review from other sources.

It should be noted that the data collected from various sources were often mutually inconsistent. That having been said, such inconsistencies did not affect the qualitative findings of these analyses. Whether the navigable depth of a river section in the dry season is 0.61 m or 0.80 m makes little difference to the conclusions.

Moreover, it should also be noted that in a number of instances data were not as complete as would have been ideal. However, gaps in data are commonplace on projects internationally. And following years of not only underinvestment in transport infrastructure (both construction of new infrastructure and maintenance of existing infrastructure) but also underinvestment in data collection, data shortfalls are to be expected. Indeed, given the significant changes that Myanmar has been undergoing in recent years, it could be argued that data on transport characteristics from a few years ago might be deemed to be less important than had Myanmar been following the same kind of 'business as usual' over the last 5 to 10 years.

But given inconsistencies and incompleteness of demand data, coupled with the estimated nature of cost data (where cost structures have likely been undergoing change in response to changing economic realities), the transport economic analyses, presented herein, neither attempt to predict likely future transport demands nor to quantify absolute costs of transport (fixed or variable). Rather, the analyses seek to identify likely trends in a more qualitative manner and to make recommendations given likely relative differences in the potential to reduce transport costs by different modes.

9.1.3 *Overview of Institutional Demarcation*

Before presenting the economic and related analyses, it is important to set out the basics of institutional demarcation, as this affects which stakeholders would be most important to any initiatives that might be identified under the broader SOBA programme as a whole - either as implementers, or potentially, as barriers.

Vessel operations are the responsibility of the vessel owners and operators, either private sector or public sector by IWT. Other institutional demarcations are as follows:

- The DWIR is responsible for dredging and the installation and upkeep of navigation aids.

[54] Stakeholders included, PMU/DWIR in Yangon on 4 September 2017; Inland Water Transport Authority in Yangon on 5 September 2017; IWVOA in Yangon on 6 September 2017; DWIR in Nay Pyi Taw on 7 September 2017; Myanmar Railways in Nay Pyi Taw on 7 September 2017; Ministry of Transport and Communications in Nay Pyi Taw on 7 September 2017; DWIR in Mandalay on 11 September 2017; the Department of Marine Administration in Mandalay on 11 September 2017; MBOA in Mandalay on 11 September 2017; CBOA in Mandalay on 11 September 2017; IWT in Mandalay on 11 September 2017; Mandalay City Development Committee in Mandalay on 12 September 2017; and Damco in Yangon on 14 September 2017.

- Once on land, local government (either at the state or regional level or at a lower level) is responsible for the land where the berthing point is located. Berthing charges can be seen as a revenue generator rather than as a service in need of improvement.
- In addition, the manual loading and unloading of vessels, the storage of cargoes on land, and then the manual loading and unloading of trucks are generally seen as employment and revenue generators rather than bottlenecks constraining the economic development of the Ayeyarwady Basin.
- However, there are more formal port facilities in Yangon - at Myanmar International Terminals, Thilawa (MITT) (on the Yangon River between Yangon and Kalaywa), at Shwepyithar (near Yangon), and at Semeikhon, Mandalay.
- Mandalay Port is managed by DWIR.
- DMA is responsible for the registration and inspection of vessels.
- Charges for use of waterways themselves are collected by township revenue offices, which are under the Ministry of Finance and Revenue.

Such demarcation, between maintaining the waterways and berthing, loading, and unloading operations, may be a barrier to the upgrading of berthing facilities. Furthermore, with revenues being collected by the Ministry of Finance and Revenue, it is unclear what, if any, hypothecation of waterway tax revenues to maintenance of IWT facilities exists.

9.1.4 Overview of Policy Context

The transport economics assessment does not pretend to be a policy appraisal. Nevertheless, during the course of stakeholder interviews, in particular, a number of policy issues were raised. While these are presented later in this report and split across different sub-sections, a summary of policy issues is provided here to improve the context of various issues identified and stakeholder concerns that were raised.

Already mentioned as an over-arching issue is the legacy of long-term underinvestment in transport infrastructure in general. In response, the government is committed to rehabilitating and upgrading the Union's transport networks, for all modes. It appears that highways are benefitting first. This contributes to the recent shift away from IWT to road transport (as documented later). However, the government is nevertheless intent on improving navigability and other conditions for IWT.

Demand for IWT has also been affected by government policies in the last few years that has restricted and curtailed logging and mining activities conducted in the upper reaches of the Ayeyarwady and Chindwin Rivers.

Meanwhile, the government has been keen to foster development of export-oriented manufacturing industries, which have long been important components of neighbouring economies (e.g., Thailand and Bangladesh). Thus far, manufacturing has been concentrated in and around Yangon. However, it was reported that a policy objective is to encourage such industries in the heartland of the country, around Mandalay, and that there are 'push' and 'pull' factors underlying this, namely:

- 'Push' factors include increasing land costs, traffic congestion (between ports and industrial areas), and constraints on electricity and water supply in Yangon.
- 'Pull' factors include cheaper and more plentiful land availability, better access to improved water-supply, and electricity-generating projects.

However, transport links between Mandalay and maritime ports are currently below par. While road networks are improving, they are unlikely to have sufficient capacity to cope with substantial development of export-oriented industries. As such, the improvement of riparian transport, including the development of containerised IWT, has been identified as a requirement to enable the development of such industry in Mandalay (i.e., to improve linkages between Mandalay and maritime shipping by means of IWT).

9.2 Extent of River Networks, Draft, and Other Navigability Restrictions

9.2.1 *Extent of Network*

Table 84 shows the extent of navigable inland waterways in Myanmar, as a whole, as of 2014. The Ayeyarwady Basin at its broadest definition includes the Ayeyarwady and Chindwin Rivers as well as the Ayeyarwady Delta, representing 4,755 km in total, or 70.5% of navigable inland water routes. The extent of these are shown in Figure 141.

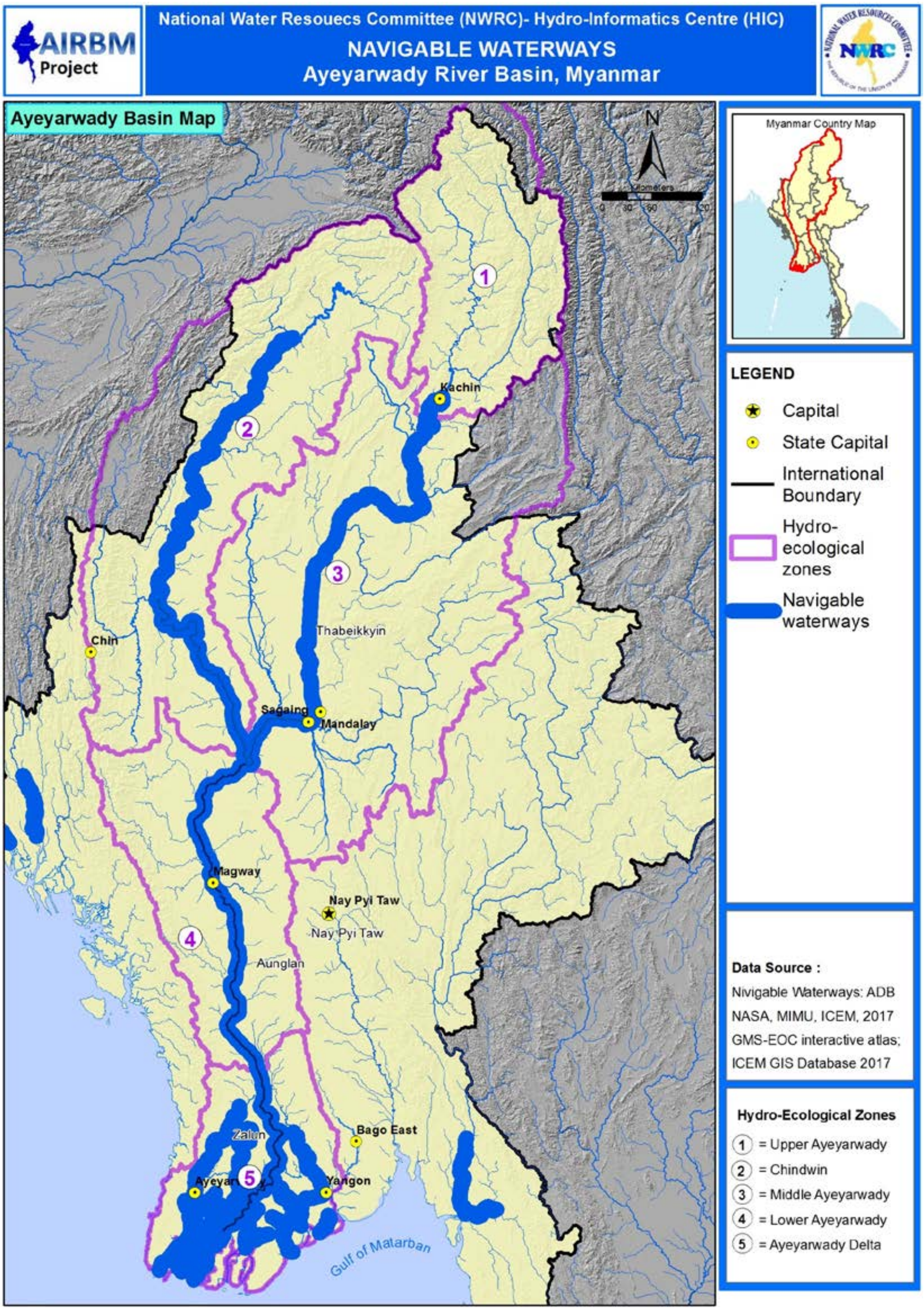


Figure 141 - Navigable Waterways

It should be noted, however, that the ADB's *Sector Policy Note for River Transport* lists the navigable length of the Chindwin River as 730 km, although it agrees with the 1,534 km figure for the Ayeyarwady, with data attributed to DWIR.

Table 84 - Navigable Length of Inland Waterways

(DWIR, Myanmar Integrated Water Resources Management: Strategic Report, 2014)

Name of river	Navigable rength (km)
Ayeyarwady	1,534
Chindwin	817
Thanlwin and other river in Mon State	380
Delta Region	2,404
Rivers in Rakhine State	1,602
Total	**6,737**

It was reported that within the Delta Region, navigation issues, such as draft limits in dry season and siltation affecting navigable channels, are not concerns to anything like the same magnitude as further upstream (and especially in the upper reaches of the Ayeyarwady and Chindwin Rivers). Most of the interventions being planned (e.g., dredging, navigation aids, and port improvements) and the vast majority of issues raised during stakeholder engagement are concerned with the Ayeyarwady Basin north and upstream of the Delta Region. Consequently, this study concentrates upon the 2,351 km of the Ayeyarwady and Chindwin Rivers and largely excludes the Delta Region.

a) Limits on Sailing Hours

While the above set out the extent of the network, it should be noted that there are a number of constraints on operating hours within a day as well as other seasonal restrictions, namely:

- In the dry season, reduced draft restricts travel on the upper reaches of the Ayeyarwady and Chindwin Rivers altogether and limits the carrying capacities of vessels on other stretches, as described in Section b.
- In the middle reaches of the Ayeyarwady, during the dry season, the presence of sandbanks can require the employment of pilots. For instance, IWT reported using three pilots for their services between Mandalay and Nyaung-U: one each between Mandalay to Myaung-mu, Myaung-mu to Pakokku, and Pakokku to Nyaung-U.
- There are also issues with navigation aids (e.g., signage), as described in Section a, that restrict sailing hours to daylight only. Some private operators reported that sailing hours are approximately 10 hours per day, due to the need to drop anchor in an appropriate location in good time.
- Other issues exist with berthing facilities, as described in Section 9.2.2.

b) Draft Limitations and Dredging

- Current Draft Limitations as Currently Understood

The above statistics do not, however, take into account draft limitations, which are particularly important during the dry season. Draft limitations are shown in Table 85, which also shows the frequency of draft limitations (in terms of days per year), with Table 86 summarising dry season draft limitations. However, it should be noted that there are conflicting data regarding water depths, with Figure 142 showing the water depths reported by JICA.

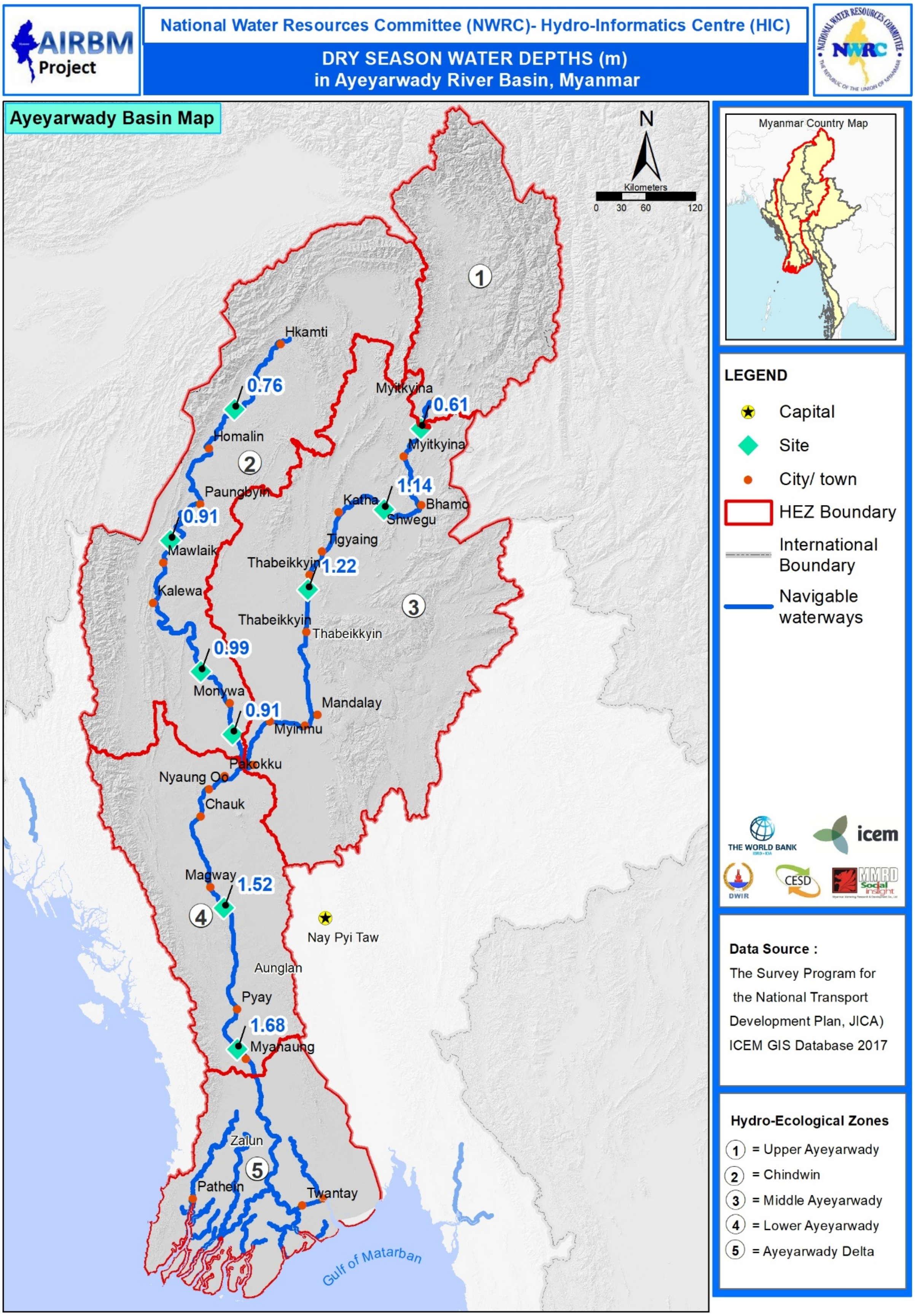


Figure 142 - Dry season water depths (m) as reported by JICA

(JICA, 2014. The Survey Program for the National Transport Development Plan)

Table 85 - Draft limitations by section of Ayeyarwady

(UNDP, 1991. Comprehensive Transport Study)

Stretch	Draft limitation for duration in days							
	1	20	30	60	90	120	150	180
Ayeyarwady River								
Yangon-Pyay	2.1	2.3	2.4	2.55	3.3	4.5	5.7	6.9
Pyay-Magway	1.05	1.2	1.3	1.5	2.05	2.85	3.7	4.5
Magway-Confluence	0.95	1.1	1.2	1.35	1.85	2.65	3.45	4.2
Confluence-Mandalay	0.95	1.25	1.35	1.5	2.1	2.95	3.85	4.75
Mandalay-Bhamo	0.75	0.95	1.1	1.25	1.8	2.65	3.5	4.4
Chindwin River								
Confluence-Monywa	0.75	0.9	0.95	1.1	1.45	2.05	2.7	3.35
Monywa-Mawlaik	0.75	0.9	1	1.15	1.5	2.05	2.7	3.45
Delta								
Delta	1.4	1.9	2.2	2.65	2.95	3.3	3.6	3.8

Table 86 - Dry season draft limits

(ADBa, 2016. Myanmar Transport Sector Policy Note: River Transport)

River sections	Depth (m)	Distance (km)
Ayeyarwady		
Myitkyina-Sinbo	0.8	90
Bhamo-Katha	1.1	130
Katha-Mandalay	1.2	290
Mandalay-Pyay	1.5	522
Pyay-Hinthada	1.7	172
Delta	1.9	n/a
Chindwin		
Hkamti-Homalin	0.8	62
Homalin-Kalewa	0.9	64
Kalewa-Monywa	1	234
Monywa-Confluence	0.9	85

These draft limits restrict the amount of cargo that may be transported. Vessel owners reported that rather than deploying specific ships for dry season conditions, especially given the prevalence of using tugs with push-barges, they typically half-load barges. For example, rather than transporting 1,500 Mt per barge (described by MBOA as a typical wet-season loading), during dry season, they would load 700-800 Mt. Furthermore, operation north of Bhamo would usually cease altogether during the dry season.

In addition to restricting operations and limiting vessel utilization (loading), dry season poses another challenge for operators. With reduced water levels, in many places the Ayeyarwady is reduced to a number of channels, thus restricting capacity. Furthermore, there is also a danger of vessels or barges grounding on sandbanks. Such navigability challenges are exacerbated by the lack of navigation aids along much of the river.

- Programme to Update River Draft Limits

Among the reasons for conflicting data on draft limits along the Ayeyarwady are the nature of the river itself. In some sections, banks of sediment can shift from year to year, which affects the course of pilotable channels. In addition, years of funding shortfalls mean that checks and maintenance went undone, and river navigation charts were not updated. DWIR has already obtained, by means of foreign aid, a number of vessels to be used in the updating river navigation charts.

- Current Financing Arrangements for Dredging and Proposals to Accelerate Dredging

Dredging is financed under two budgets: At the Union level and at the Region/State level. In addition to this, loan aid is also being used.

In order to increase the navigable depths in the dry season along the Ayeywarwady River, DWIR is currently negotiating a US$ 100 million loan with the World Bank and discussing aid with the Belgian Government.

Should these aid packages be approved, then dredging would be undertaken to increase navigable river depths in the dry season. It is understood that the intention is to dredge stretches in sequence, with the aim of gradually increasing river depths overall. Such a method would increase the navigable depths for longer distance trips, rather than just benefitting individual stretches that would limit the length of newly enabled journeys by vessels with deeper drafts.

a) Navigation Aids

- Current Issues

Navigation signage is present along the river. However, it was reported that signs are often washed away. A further issue is that, traditionally, these signs have been made of locally available, low cost materials, which not only wash away more easily but also are not always visible to vessels plying the river. The width of the river in some sections also reduces the visibility of such navigation aids. Figure 143 shows a navigation aid viewed from mid-river, taken using a camera with a strong zoom lens.

In addition to issues with navigation aids, DWIR also cited an issue with the designs of a number of river bridges. When built, these often did not remain due to a lack of consideration of navigation requirements, which resulted channels too narrow for vessels to pass. Figure 144 shows the Ayeyarwady River Bridge at Pakokku. The main bridge is 3.4 km long, but individual columns are relatively closely spaced. However, it is understood that the individual spans of the Pakokku Bridge are relatively broad as compared to those on certain other bridges.

As a consequence of navigational constraints, nighttime sailing is prohibited along most of the Ayeyarwady River and the Chindwin River. This restricts the efficiency of vessels, impacts on journey times, and increases transport costs.

Figure 143 - A navigation aid

(Study Team)

Figure 144 - Ayeyarwady River Bridge at Pakokku

(Study Team)

- Measures to Address Navigability Challenges

As informed by DWIR, measures are being considered to address navigation issues, namely dredging (described in the previous sub-section) and upgrading navigation aids. These are currently being negotiated between DWIR and the Belgian Government (i.e., as aid) and the World Bank. These include US$ 1.6 million support from the Belgian Government to improve navigation signage equipment (though this agreement has yet to be finalised).

9.2.2 *Port and Berthing Facilities*

a) Current Port and Berthing Arrangements

While there are container facilities and full facilities for general cargo along the Yangon River (e.g., MITT), this is not the case along the Ayeyarwady River and Chindwin River.

There is a gantry crane at Semeikhon Port, near the confluence with the Chindwin River (shown in Figure 145). At Mandalay, there are some permanent berthing facilities for general cargo, but these have been deemed insufficient; hence, there are proposals to upgrade Mandalay Port and to provide container facilities (see Section c). At a number of points, in the absence of permanent, land-mounted cranes, floating cranes mounted on barges are used, with an example from Sagaing region shown in Figure 146. At other points, sand is transferred by excavator, with an example from downstream of Mandalay shown in Figure 147. Figure 148 shows an example of an excavator aboard a ship.

Figure 145 - Gantry crane and barge crane at Semeikhon

(Photo by Study Team)

Figure 146 - Floating cranes on barges at Sagaing

(Photo by Study Team)

Figure 147 - Sand being moved by an excavator, near Mandalay

(Photo by Study Team)

Figure 148 - Example of excavator aboard a vessel

(Photo by Study Team)

At most locations, the loading and unloading of cargoes is dependent upon manual labour using plank-walks. Similar plank-walk arrangements are the norm for passengers boarding and disembarking, with an example from Nyaung-U shown in Figure 149. Such arrangements result in significant delays for boarding and alighting of passengers and loading and unloading of cargoes, as compared to what would be the case with more appropriate berthing, loading, and unloading facilities.

Figure 149 - Example of planks used for boarding and alighting

(Study Team)

Private shipowners reported that, in response to poor facilities at formal ports and berthing points coupled with charges (see Table 87 and Table 88), they will often eschew formal berthing facilities, either on their own initiative or under instruction from those chartering their vessel. Instead, they will locate a site where they can get close enough to shore to drop anchor and then set up their own plank arrangements. The suitability of any given point to drop anchor can vary according to season. Wherever possible, they will seek locations where trucks can back right up to the riverbank so that goods may be transferred directly between vessel and truck, or vice versa.

b) Port Charges and Loading and Unloading Charges

ADB (2016) cites IWT, Table 87 shows daily port charges typically levied according to the size of the vessel.

Table 88 summarises standard loading and unloading charges for vessels.

Table 87 - Port Charges (kyats per day)

(ADB 2016)

Vessel length (feet)	Rate
25	500
25-50	1,000
50-75	1,500
75-100	2,000
100-125	2,500
125-150	3,000
150-175	3,500
175-200	4,000
200-225	4,500

Vessel length (feet)	Rate
225-250	5,000
250-275	5,500
275-300	6,000

Table 88 - Loading and unloading charges (kyats per t)

(ADB 2016)

Commodity	Rate	Remarks
Rice	2,625	
Cement	2,730	
Fertiliser	2,730	
Timber	16,900 33,800 50,700	4’ by 4’ (lower) 4’ by 4’ (upper) 6’ by 6’ (upper)
Iron	8,450	
Furniture	13,000	
Miscellaneous	8,450	

- Floating Warehouses

Private vessel operators, in particular the MBOA, stated that, at present, ship charterers want to avoid paying cargo storage charges on land, so they often keep cargoes on barges as ‘floating warehouses.' Under current market conditions, vessel owners are unable to charge for demurrages without risking losing business.

- Unsheltered and Insecure Storage of Cargoes

The comments from some private operators - use of vessels as floating warehouses notwithstanding - indicate that there is a lack of proper cargo storage facilities at most supposed ports along the Ayeyarwady and Chindwin Rivers. This leaves cargoes not only exposed to the elements but also at increased risk of theft. Figure 150 is a photograph from IWT showing typical arrangements at present, with cargoes exposed to the elements and not secured. As such, proper, secure facilities for the storage of cargoes should be developed.

Figure 150 - Example of manual cargo handling and unsheltered storage of cargoes

(IWT)

- Loading and Unloading Costs at Private Facilities

Private vessel owners and IWT stated that loading and unloading costs at private facilities, such as MITT and Shwepyithar, are prohibitively expensive. They stated that this contributes to declining business for river transport, while boosting the attractiveness of road transport.

For example, IWT's Yangon Office provided a comparison of charges between trucking and IWT, with reference to shipping a container between MITT (south of Yangon) and Shwepyithar (on the outskirts of Yangon). The resuls are as follows:

- Cost via truck: 60,000 - 70,000 kyats per container, including insurance.
- Cost via shipping: 6,000 kyats for shipping, plus 40,000 kyats to load at MITT, plus 40,000 kyats to unload at Shwepyithar = 86,000 kyats, with additional insurance required.

This was likely a reason why both IWT and private shipowners were sceptical about the potential benefits of port upgrading proposals, especially those pertaining to containerisation (as discussed in Section c).

c) Plans for Upgrading Mandalay Port

- Mandalay Port

Operated by DWIR, Mandalay Port is seen as the key port along the Ayeyarwady-Chindwin River system (i.e., north of the Delta Region and Twante Canal). As per the 2015 Navigation Study, its throughput was 1.23 Mt (of which just over 1 million Mt were goods offloaded; see Section a). However, the JICA (undated) reckons that current throughputs are approximately 616,000 Mt per annum (see Section b).

Despite Mandalay Port's strategic importance, there has been little investment into Mandalay Port since its inception approximately 130 years ago. Consequently, it remains largely dependent upon manual labour practices, and its facilities are in poor condition. These factors will constrain scope for growth.

Mandalay Port is seen as a potential pivot for growth for the following reasons:

- Mandalay is the economic hub of central Myanmar.
- Mandalay Port provides connectivity between trucks travelling to and from China (primarily via the Muse-Ruili border crossing).
- As discussed in Section f, there are plans to develop industry in Mandalay, in part to relieve pressure on Yangon, where there are land price, water, and electricity constraints.

While plans for Mandalay Port are not yet finalised, the meeting with DWIR's Mandalay Office concentrated upon the JICA proposals for Mandalay Port. Key points are as follows:

- JICA's plans for Mandalay port cover a 32-acre site, with a 180 m long river frontage.
- The project will be financed by a JICA grant.
- There would be one jetty.
- Warehousing facilities and container cranes are included, in addition to general cargo facilities.
- JICA would build the facility and transfer it.

The Consultants received mixed feedback when discussing the development plans for Mandalay Port's container terminal with vessel operators (discussed in more detail in Section 9.2.7), with concerns cited including:

- The absence of demand for containerised transport/absence of other container ports along the Ayeyarwady and Chindwin Rivers. Though such absence of container traffic should be expected given the absence of facilities for containers at the current time. Nevertheless, this does signal a potential risk for the container port: demand would need to increase from zero and might also be dependent upon the development of container facilities at other Ayeyarwady Ports (with no such other facilities currently at advanced planning stages).

- Given the level of container loading and unloading charges at MITT and Shwepyithar, there are concerns regarding the affordability of any such charges at Mandalay.
- A number of private shipowners interviewed are currently more concerned with demand levels for their businesses than with adding capacity.

Given the above, the success of container facilities is likely to be heavily dependent upon the successful and timely implementation of Union-level policies to develop Mandalay into a new industrial hub. As such, the success of Mandalay Port's proposed container terminal and the success of plans to develop Mandalay into an industrial hub would appear to be dependent upon one another. Such a situation embodies substantial risk for private investors; however, the JICA assistance deemed likely should overcome such financing risks.

Although private operators were sceptical regarding the container terminal plans, it should be noted that they were overwhelmingly supportive of proposals to substantially improve facilities for general cargo, which were also part of the same JICA assistance.

- Other Ports

In addition to Mandalay Port itself, DWIR's Mandalay Office reported that the JICA (undated) also recommends development of other river ports, and that such river ports might qualify for further assistance from JICA, though this has not yet been confirmed. In addition, DWIR's Nay Pyi Taw Office reported that the Belgian Government and the World Bank may also participate in river port development.

The ports mentioned by DWIR as being considered for such upgrades - primarily for handling of general cargoes - included the following:

- On the Chindwin River, at Monywa and Kalewa;
- On the Ayeyarwady, at Bhamo, Kathar, Pakokku, Magway, Myingyan, Pyay, and Hinthata; and
- At Yangon Port, either on the Yangon River or Bago River.

Such upgrading works for general cargoes were supported by private shipowners and by IWT when queried on the subject. They are keen to be able to decrease time spent loading and unloading, so that they can spend more time sailing.

DWIR reported that it would likely be approximately five years until such upgrades would be completed, assuming that financing is secured.

In addition, DWIR reported plans for public-financed construction of a new cargo terminal near the confluence of the Myingwe and Ayeryawady rivers. However, these plans are still in their early stages.

9.2.3 *Historical Trends in Inland Water Transport versus Road Transport*

a) Introduction

A study on IWT is presented in Nam and Win (2014). This analyses data spanning the period 2003 - 2012 in most detail, but also includes some data stretching back to the 1985/86 fiscal year.

This paper presents historical data on IWT, comparing volumes against those for road transport, as presented in Section b.

In addition, Nam and Win (2014) analysed typical journey times and costs between Yangon and Mandalay, as discussed in Section 0.

b) Historical Data on Volumes

Nam and Win (2014) report freight modal split as shown in Figure 151, wherein it can be seen that water transport enjoyed substantial growth from the 1985/86 fiscal year up until 2010/11, with a noticeable and unexplained decline in 2011/12.

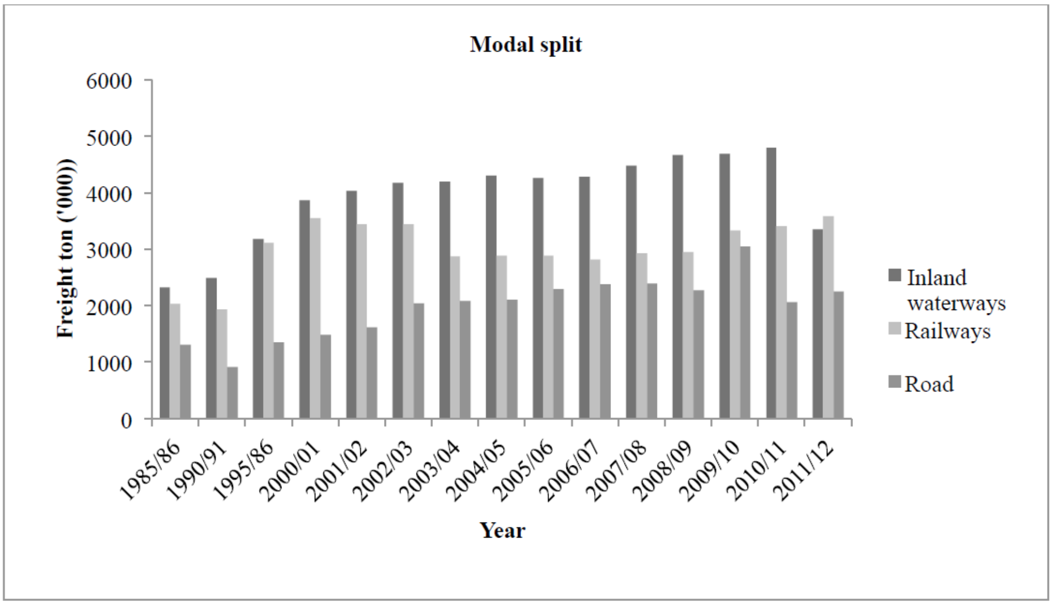


Figure 151 - Freight Modal Split 1985/1986 to 2011/2012

(Nam and Win 2014)

Data on annual tonne-kilometre (tkm), tonnages, and average transport distances by inland water and by road haulage are given in Table 89. If 1990/91 and 1995/96 data are set aside, it can be seen that average transport distances by inland water have grown over the period 2000/01 to 2009/10, whilst the same can be said for road haulage trips from 2003/04.

Table 89 - Inland water and road haulage volumes

(Nam and Win 2014)

Fiscal year	Inland Water			Road		
	Thousand tkm	Thousand t	Average distance (km)	Thousand tkm	Thousand t	Average distance (km)
1990/91	521,029	2,489	209	115,260	914	126
1995/96	516,162	3,177	162	221,090	1,352	164
2000/01	551,010	3,863	143	284,840	1,485	192
2003/04	683,400	4,192	163	353,051	2,081	170
2004/05	725,374	4,307	168	370,311	2,108	176
2005/06	728,280	4,262	171	406,619	2,349	173
2006/07	831,973	4,284	194	423,884	2,380	178
2007/08	930,944	4,479	208	456,378	2,399	190
2008/09	1,023,110	4,658	220	472,364	2,416	196
2009/10	1,099,531	4,685	235	473,421	2,411	196

In all years for which data are given in Table 89, inland water accounts for more tonnes transported and more tonne-kilometres. Table 90 shows the ratio of inland water performance to road performance for each fiscal year (i.e., the inland water value from Table 89 divided by the equivalent value for road haulage in each case). These ratios show:

- In 1990/1991, IWTed 2.72 times as many tonnes as road haulage, with this ratio declining to 1.80 times by 2006/2007, thereafter growing back to 1.94
- In terms of tonne-kilometres, in 1990/1991, inland water accounted for 4.52 times the amount by road haulage, declining to 1.93 times by 2000/01, after which the ratio grew again, reaching 2.13 by 2009/2010
- In 1990/91 and from 2006/07 onwards, inland water trips on average were longer than those by road, though this pattern reversed from 1995/1996 to 2005/2006.

Table 90 - Ratios of Inland Water to Road Haulage Performance

(Nam and Win 2014; Study Team)

Fiscal year	Ratio of Inland Water Data to Road Data (using data from Table 89)		
	tkm	t	Average distance
1990/91	4.52	2.72	1.66
1995/96	2.33	2.35	0.99
2000/01	1.93	2.60	0.74
2003/04	1.94	2.01	0.96
2004/05	1.96	2.04	0.96
2005/06	1.79	1.81	0.99
2006/07	1.96	1.80	1.09
2007/08	2.04	1.87	1.09
2008/09	2.17	1.93	1.12
2009/10	2.32	1.94	1.20

In order to understand trends within either the inland water or road haulage mode,Table 91 takes data from Table 89 and indexes these data to 2003/2004 values. It can be seen that both t and tonne-kilometre figures have grown since 2003/2004, with road transport growing faster in terms of total t transported, whilst inland water grew more in terms of tonnne-km transported.

Table 91 - Indexed Values from Nam & Win (2003/2004 = 100)

(Nam and Win 2014; Study Team)

Fiscal year	Inland water			Road		
	Thousand tkm	Thousand t	Average distance (km)	Thousand tkm	Thousand t	Average distance (km)
2003/04	1.00	1.00	1.00	1.00	1.00	1.00
2004/05	1.06	1.03	1.03	1.05	1.01	1.04
2005/06	1.07	1.02	1.05	1.15	1.13	1.02
2006/07	1.22	1.02	1.19	1.20	1.14	1.05
2007/08	1.36	1.07	1.27	1.29	1.15	1.12
2008/09	1.50	1.11	1.35	1.34	1.16	1.15
2009/10	1.61	1.12	1.44	1.34	1.16	1.16

c) Journey Time Comparisons: between Yangon and Mandalay

Nam and Win (2014) also analysed differences in journey times and costs between inland water and road, focusing on journeys between Yangon and Mandalay. It should be noted that their analyses concentrated on the 'main haul' between Yangon and Mandalay and as such exclude data on typical first and final legs of journeys within either of the cities. This simplification was made due to the additional complexities and resources that would have been required to collect such data.

However, it should be noted that as such this does not constitute a fully 'like for like' comparison. Inland water traffic would almost certainly require transfer from/to trucks for initial and final journey legs. While consolidation/deconsolidation might be required for road freight shipments also, this would not always be the case and where it is still the case, truck-to-truck rather than intermodal transfers may well be easier. As described in Section a, river-to-road transfers take place at a variety of locations, often entailing improvised, informal transfer arrangements at unofficial berthing points. Furthermore, as stated in Section b, warehousing facilities are often lacking in formal berthing facilities (as is also the case at informal berthing points).

These caveats notwithstanding, Nam and Win (2014) estimated journey distances, speeds, and durations between Yangon and Mandalay as set out in Table 92.

If estimates of loading and unloading times are included, then time estimates for inland waterway are as shown in Table 93, with a round trip taking 18 days, assuming there are no delays with finding cargoes. The equivalent round trip for a truck is estimated at just five days, as shown in Table 94.

Table 92 - Estimated typical journey distance, time, and speed between Yangon and Mandalay

(Nam and Win 2014)

	Road	Inland waterway
Distance	750 km	917 km
Speed	Under 40 mph (under 64 kph)	Mandalay to Yangon: 10 knots Yangon to Mandalay: 6 knots
Travel time	36 - 40 hours	7 days

Table 93 - Estimated inland water journey times between Mandalay and Yangon by direction

(Nam and Win 2014)

Activity	Mandalay to Yangon (downstream)	Yangon to Mandalay (upstream)
Loading at port	1 day	1 day
Actual sailing time	6 days	8 days
Discharging	1 day	1 day
Total	**8 days**	**10 days**

Table 94 - Estimated road freight journey times between Mandalay and Yangon

(Nam and Win 2014)

Activity	Number of days
Collecting & loading cargo	1
Line haul (head)	1.5
Line haul (back)	1.5
Collecting cargo for backhaul	1
Total	**5**

d) Cost Comparisons: between Yangon and Mandalay

Nam and Win's (2014) analyses assume a 1,000 t capacity barge and an 18-wheeler semi-trailer with a 26 t capacity, as being representative for inland water and road transport respectively. Assuming a 75% capacity utilization factor (two-way), the amount of cargo transported on one round trip is therefore:

- For inland water: 1,000 x 2 x 75% = 1,500 Mt per round trip
- For road haulage: 26 x 2 x 75% = 39 Mt per round trip.

They excluded insurance from their calculations. Annual costs for running a barge were estimated as shown in Table 95, with annual truck costs estimated as shown in Table 96.

Table 95 - Annual operating costs for a 1,000 t barge *(Nam and Win 2014)*

Item	Amount (kyats)
Fixed Costs	
Insurance	0
Crew cost (150,000 x 2 x 12)	7,200,000
Personnel cost	3,000,000
Other costs	1,500,000
Subtotal (1)	11,700,000
Variable Costs	
Diesel (180,000 x 40 drums x 10)	72,000,000
Lubricants (5 gallon x 15,000 x 10)	750,000
Maintenance & repair	5,700,000
Subtotal (2)	78,450,000
Total (1)+(2)	**90,150,000**

Table 96 - Annual operating costs for a truck

(Nam and Win 2014)

Item	Amount (kyats)
Fixed Costs	
Driver cost (driver + assistant)	20,000,000
Insurance	0
tax	800,000
Technical inspection	60,000
Other costs (admin, etc.)	200,000
Subtotal (1)	21,060,000
Variable Costs	
Diesel (120 gallon x 100 trips x 3600)	43,200,000
Lubricants (gallon 30 per year x 3600) x 15,000	450,000
Tyres (1 tyre for each six months)	5,760,000
Repair and maintenance	2,000,000
Toll fees (105.6 kyats/km x 1,500km x 100)	15,840,000
Other costs	200,000
Subtotal (2)	67,450,000
Total (1)+(2)	**88,510,000**

e) Costs per tonne transported by inland water

- By Inland Water

Nam and Win (2014) estimated that in practice a barge would undertake 10 round trips per annum, with a 75% average loading factor, meaning that the total cargo transported per year per barge would be:

- 1,000 Mt x 2 x 10 x 75% = 15,000 Mt per annum.

Consequently, one round trip would cost 90,150,000 ÷ 10 = 9,015,000 kyats, and moving one t between Yangon and Mandalay (or vice versa) would cost 6,010 kyats on average.

- By Road

Nam and Win (2014) allowed for 100 round trips by truck between Yangon and Mandalay, even though this is more than would be suggested possible according to their estimates in Table 94. Assuming 100 round trips per annum were feasible by truck, and applying the same 75% average load factor, the total cargo transported per year per 18-wheel truck would be:

- 26 Mt x 2 x 100 x 75% = 3,900 Mt per annum.

Consequently, one round trip would cost 88,510,000 ÷ 100 = 885,100 kyats, and moving one t between Yangon and Mandalay (or vice versa) would cost 22,695 kyats on average.

- Comparison

Comparing the costs per t presented above, road hauling one t of cargo is estimated to cost 277% more than transporting the same cargo by barge.

It should be noted that these findings would appear to contrast with the arguments presented by private ship owners and IWT to the Consultants as described in Section c in particular.

Differences may be partially attributable to Nam and Win (2014) being an older paper, based on data pre-dating the liberalisation of import policies affecting second-hand road vehicles, among other things. Also, Nam and Win (2014) concentrated on transport between Yangon and Mandalay, as opposed to transport between Thilawa and Shwepyithar.

These differences would nevertheless highlight the fact that implementing upgraded facilities along the river is not likely to be sufficient to effect change. Charging schedules for use of improved facilities should not be such that they dissuade too many potential users from employing such improved facilities.

9.2.4 JICA Survey Program Estimates of Union-wide Transport Patterns

a) Introduction

Regarding overall (nationwide) data by mode, JICA (2014) provides nationwide estimates of current (as of 2015) and forecast (2030) volumes and mode share.

In the absence of a full multi-modal study of the Ayeyarwady Basin itself, this JICA Survey Program appears to be the most complete reference source currently available.

b) Current passenger demand and mode share

The JICA Survey Program estimated current passenger transport demand as shown in Table 97. Note however that this table omits short-distance trips, as Myanmar is divided into just 71 zones. Equivalent data, also including plots of trip distances, are shown in Figure 152.

Table 97 - Current transport demand estimate

(JICA 2014)

Mode	Interzonal trips per day	Modal share (%)	Passenger-km (thousands)	Average distance (km per trip)
Air	7,282	2	4,559	626
Car	68,414	23	14,479	212
Bus	160,042	53	62,689	392
Rail	55,286	18	16,985	307
IWT	9,421	3	3,470	368
Total	300,445	100	102,182	340

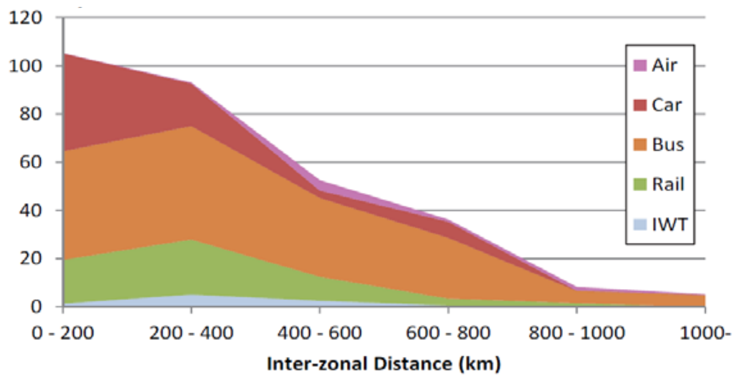


Figure 152 - Passenger Transport Demand (thousand trips per day) by mode versus length

(JICA 2014)

Estimated passenger mode share for waterways is just 3% of the total, only marginally more than for air (2%). Rail captures 18% while road (car plus bus) accounts for the remaining 77%, illustrating roads' domination over passenger mode share at the national level.

c) Estimates of Current Freight Demand and Mode Share

Table 98 shows JICA (2014) estimates of year 2015 freight demand by mode, with corresponding mode split figures given in Table 99.

Table 98 - Cargo volume estimates (thousand Mt per day), 2015

(JICA 2014)

Commodity	Truck	River	Railway	Coastal	Total
Live animals and animal products	1.7	0	0	0	1.8
Fish and aquatic products	3.1	0	0	0	3.1
Vegetable and fruits	6.6	0	0	0	6.6
Grain and grain products	38.7	0.5	0.2	1.5	40.9
Other agricultural products	18	0.6	0	0	18.6
Foodstuff, beverage and animal food	22	0.5	2.1	4.4	28.9
Petroleum, oil and gas	8.8	1.7	0	15.8	26.2
Coal, ore, stone and sand	10.1	0.1	0.4	0	10.6
Cement, construction material, steel frames	30.9	0.7	1.1	1.4	34.1
Fertilizer (including urea)	15.5	0	0	0	15.6
Garment, textiles, wood and fabric	3.9	0	0	0	3.9
Wood and wood products	5.9	0.2	0.2	0	6.3
Paper and printed matter	1.6	0	0	0	1.6
Metal and metal products (excluding construction materials)	2.5	0.1	0.1	0	2.6
Industrial material, chemicals	7.6	0.3	0.1	0.4	8.4
Household articles, miscellaneous	25.3	1	0.4	0.3	27
Machinery and parts, transportation	9.5	0	0.1	0	9.7
Total	211.7	5.7	4.7	23.8	246
Mode Share	86%	2%	2%	10%	100%

Table 99 - Cargo volume mode share estimates (%), 2015

(JICA 2014)

Commodity	Truck	River	Railway	Coastal	Total
Live animals and animal products	94%	0%	0%	0%	100%
Fish and aquatic products	100%	0%	0%	0%	100%
Vegetable and fruits	100%	0%	0%	0%	100%
Grain and grain products	95%	1%	0%	4%	100%
Other agricultural products	97%	3%	0%	0%	100%
Foodstuff, beverage and animal food	76%	2%	7%	15%	100%
Petroleum, oil and gas	34%	6%	0%	60%	100%
Coal, ore, stone and sand	95%	1%	4%	0%	100%
Cement, construction material, steel frames	91%	2%	3%	4%	100%
Fertilizer (including urea)	99%	0%	0%	0%	100%
Garment, textiles, wood and fabric	100%	0%	0%	0%	100%
Wood and wood products	94%	3%	3%	0%	100%
Paper and printed matter	100%	0%	0%	0%	100%
Metal and metal products (excluding construction materials)	96%	4%	4%	0%	100%
Industrial material, chemicals	90%	4%	1%	5%	100%
Household articles, miscellaneous	94%	4%	1%	1%	100%
Machinery and parts, transportation	98%	0%	1%	0%	100%

These reported mode shares for IWT appear very low, especially for bulk commodities. The differences in comparison to the data presented from just a few years ago by Nam & Win are also quite marked (see Figure 151 for example). This raises suspicion of systematic underestimation of inland water cargo volumes. For instance, it could be that JICA's methodology was biased towards public sector data sources on riparian transport, resulting in under-reporting of private inland shipping. However, such suspicions cannot be confirmed based on data available and as such are conjecture.

Likewise, it is not clear how volumes being transported on journeys lasting multiple days are handled. Assuming that these estimates have been prepared using orthodox transport demand forecasting techniques, then these figures would relate to daily demands added to the transport network (i.e., goods on a vessel for one week might be counted just as one day's demand, rather than being counted on each of the days of the journey). Such an approach would be inferred from how mode share is calculated, i.e., being calculated solely on the basis of volumes transport annually then divided by 365, rather than taking account of tonne-kilometres or tonne-days.

Another possibility is that oil and gas, for example, were allocated to coastal transport rather than being included in both coastal and riparian transport. If riparian and coastal transport are combined, then the combined overall mode share as per Table 98 becomes 12% which might be a better estimate.

In any event, and even allowing for the possibility of serious under-reporting of inland water mode share by the JICA (2014), this would suggest that the mode share for cargo transported by inland waterways has fallen substantially in recent years.

d) Forecast Estimates of Future Freight Demand and Mode Share

Similar to the above, Table 100 presents 2030 forecasts from the JICA (2014) with mode choice figures in Table 101.

Table 100 - Cargo volume forecast estimates (thousand Mt per day), 2030 *(JICA 2014)*

Commodity	Truck	River	Railway	Coastal	Total
Live animals and animal products	4.2	0.1	0	0	4.3
Fish and aquatic products	13	0	0	0	13
Vegetable and fruits	15.5	0	0	0	15.6
Grain and grain products	157.4	3.2	1.8	4.4	166.9
Other agricultural products	104	5	0.8	0	109.9
Foodstuff, beverage and animal food	56.2	3.5	7.6	8.9	76.2
Petroleum, oil and gas	30.3	21	1.9	63.9	117.1
Coal, ore, stone and sand	63.4	0.8	2.6	0	66.9
Cement, construction material, steel frames	136.9	10.1	15.5	4.2	166.7
Fertilizer (including urea)	33.3	0.2	0.2	0	33.7
Garment, textiles, wood and fabric	9.4	0.3	0.1	0	9.8
Wood and wood products	9.1	1.1	4.2	0	14.4
Paper and printed matter	3.1	0	0.1	0	3.2
Metal and metal products (excluding construction materials)	5.8	0.3	0.8	0	6.9
Industrial material, chemicals	19.6	0.9	1	0.9	22.3
Household articles, miscellaneous	106.2	7.1	2.8	0.8	116.8
Machinery and parts, transportation	27.4	0.5	0.3	0.1	28.3
Total	794.9	54.3	39.8	83.1	972.1
Mode Share	87%	2%	2%	9%	100%

Looking at these forecasts, the mode share for inland waterways appears quite low, especially for bulk commodities. A 2% mode share for freight is seen in both 2015 and 2030 according to JICA, which either seems low or suggests that the potential for bulk commodity transport by IWT has been estimated rather conservatively.

If coastal shipping is combined to riparian shipping, then mode share become 11%, which is lower than in 2015 (12%). This perhaps implies assumptions close to business as usual, rather than taking account of development potential for IWT.

In any event, it can be seen that the JICA (2014) expects road to maintain its dominant position for freight (growing from 86% in 2015 to 87% in 2030).

Table 101 - Cargo volume mode share estimates (%), 2030 *(JICA 2014)*

Commodity	Truck	River	Railway	Coastal	Total
Live animals and animal products	100%	2%	0%	0%	100%
Fish and aquatic products	100%	0%	0%	0%	100%
Vegetable and fruits	99%	0%	0%	0%	100%
Grain and grain products	97%	0%	0%	3%	100%
Other agricultural products	98%	2%	0%	0%	100%
Foodstuff, beverage and animal food	81%	0%	7%	12%	100%
Petroleum, oil and gas	40%	6%	0%	55%	100%
Coal, ore, stone and sand	96%	1%	4%	0%	100%
Cement, construction material, steel frames	95%	0%	2%	3%	100%
Fertilizer (including urea)	100%	0%	0%	0%	100%
Garment, textiles, wood and fabric	100%	0%	0%	0%	100%
Wood and wood products	97%	3%	1%	0%	100%
Paper and printed matter	100%	0%	0%	0%	100%
Metal and metal products (excluding construction materials)	97%	1%	1%	0%	100%
Industrial material, chemicals	95%	0%	2%	4%	100%

Commodity	Truck	River	Railway	Coastal	Total
Household articles, miscellaneous	97%	1%	1%	1%	100%
Machinery and parts, transportation	99%	0%	0%	0%	100%

9.2.5 *Estimates of Current Port Throughputs*

a) 2015 Navigability Study

The '*Feasibility study on the improvement of the navigability of the Ayeyarwady River in Myanmar*' conducted for Enterprise Agency Netherlands by HaskoningDHV Nederland B.V., in association with Arcadis and Rebelgroup (Haskoning DHV 2015), was published in 2015.

Haskoning DHV (2015) estimates annual cargo volumes by stretch of the Ayeyarwady River as shown in Table 102, with throughputs by individual ports as shown in Table 103.

Table 102 - Annual cargo volumes (Mt p.a.) by stretch of Ayeyarwady River

(Haskoning DHV 2015)

From	To	Volume (Mt p.a.)
Yangon	Pyay	2,080,000
Pyay	Magwe	1,960,000
Magwe	Nyaung U	1,900,000
Nyaung U	Pakokku	1,810,000
Pakokku	Myin Mu	1,740,000
Myin Mu	Mandalay	1,560,000
Mandalay	Katha	490,000
Katha	Mines	440,000
Mines	Bhamo	170,000

It can be seen that vessel sizes operable in the Upper Ayeyarwady are smaller than in the rest of the river system, though similar limits are understood to apply along much of the Chindwin. It is also noticeable from Table 103 that there is a marked imbalance between cargoes brought to and cargoes exported from Mandalay port in particular. At the Union-wide (national) level there are plans to expand industrial employment and production around Mandalay, which, if successful, would address this imbalance (this is discussed in Section f). Furthermore, such initiatives would likely work hand-in-hand with plans to upgrade Mandalay Port (see Section c).

Table 103 - Annual port throughputs (Mt p.a.) (*Haskoning DHV 2015*)

Port(s)	Vessel size (DWT)	Import	Export	Annual throughput
Yangon	1,000	450,000	1,350,000	1,800,000
Ayeyarwady Delta	1,000	0	280,000	280,000
Pyay	1,000	20,000	100,000	120,000
Magwe	1,000	30,000	30,000	60,000
Nyaung U	1,000	70,000	20,000	90,000
Pakokku	1,000	30,000	40,000	70,000
Myin Mu	1,000	170,000	10,000	180,000
Mandalay	1,000	1,020,000	210,000	1,230,000
Katha	500	40,000	30,000	70,000
Mines	500	250,000	20,000	270,000
Bhamo	500	130,000	120,000	250,000

Port throughputs by cargo type were estimated as shown in Table 104.

Table 105 shows estimates of current cement movements along the Ayeyarwady, with production concentrated at present in Yangon, with Mandalay operating as a secondary production area.

Table 104 - Annual port throughputs by cargo type (thousand Mt p.a.)

(Haskoning DHV 2015)

Port(s)	Coal	Cement	Rice	Gravel/ Sand	Liquid Bulk	Beans/ Agri	Misc. House-hold	Wood	Sugar
Yangon	250	90	0	150	870	110	160	120	50
Delta	0	0	280	0	0	0	0	0	0
Pyay	0	10	0	100	100	0	10	0	0
Magwe	0	10	10	20	20	10	10	0	0
Nyaung U	0	0	0	10	10	10	10	0	0
Pakokku	0	10	10	20	20	20	10	0	0
Myin Mu	0	10	0	0	0	10	10	0	0
Mandalay	0	80	300	0	0	60	140	0	50
Katha	0	10	10	0	0	0	10	20	0
Mines	250	0	0	0	0	0	20	0	0
Bhamo	0	20	40	0	0	0	40	100	0
Total	500	240	650	300	1020	220	420	240	100

Table 105 - Estimated current cement movements along Ayeyarwady River

(Haskoning DHV 2015)

To	From		
	Yangon	Mandalay	Total to
Yangon	0	0	0
Delta	0	0	0
Pyay	10,000	0	10,000
Magwe	10,000	0	10,000
Nyaung U	0	0	0
Pakokku	10,000	0	10,000
Myin Mu	10,000	0	10,000
Mandalay	50,000	0	50,000
Katha	10,000	10,000	20,000
Mines	0	0	0
Bhamo	20,000	20,000	40,000
Total	**120,000**	**30,000**	**150,000**

Figure 153 - Coal Being Transported along the Ayeyarwady

(Study Team)

Figure 154 - Barge Carrying Rice, with Push-Tug on Starboard

(Study Team)

Figure 155 - Barge with partial load and push-tug

(Study Team)

b) JICA Mandalay Port Study

The JICA-financed Mandalay Port Development Project (JICA, undated) summarises current cargo volumes at Mandalay Port as shown in Figure 156. Figure 157 shows JICA's forecasts of likely future port usage, including a decline in current riverbank arrangements, following implementation of the Mandalay Port project.

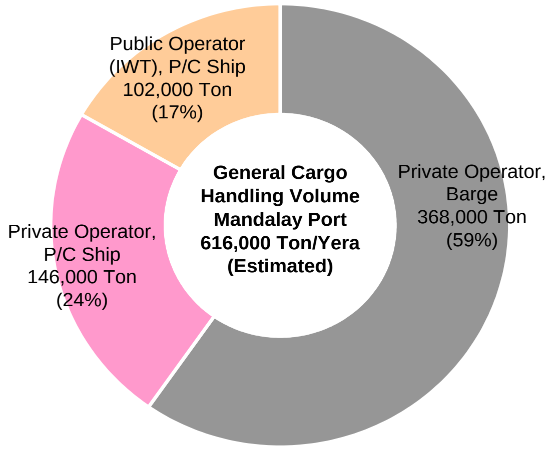


Figure 156 - Current cargo volumes at Mandalay Port

(JICA, undated)

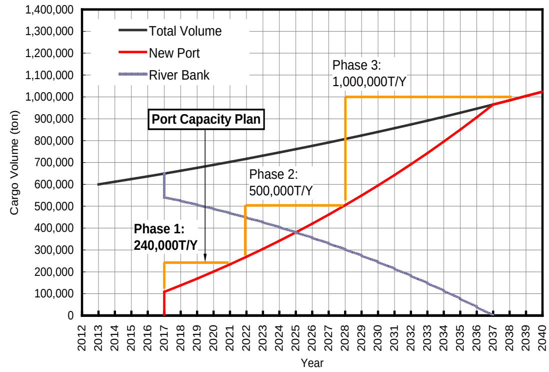


Figure 157 - Forecast capacity and throughput evolution at Mandalay Port

(JICA, undated)

The JICA (undated) additionally forecasts that the port development would reduce road transport movements to/from Mandalay by 27%, resulting in reduction in CO_2 emissions amounting to 15,000 Mt per annum.

9.2.6 *Data from Vessel Transit Charges*

Data presented in preceding Sub-Sections were estimated data. In this Section, direct empirical data obtained from revenue offices along waterways are presented and analysed. Figure 158 presents a schematic diagram, showing the relative locations of different Revenue Offices within the Ayeyarwady Basin system. These data were provided by the Ministry of Finance and Revenue (MFR). Data were available as shown in Table 106.

Table 106 - Availability of Revenue Data by Revenue Office

(MFR)

Revenue office	Data from	Data to
Katha	Mar 16	Jul 17
Mandalay	Dec 15	Jul 17
Monywa	Aug 15	Jul 17
Magway	Jun 15	Jul 17
Pyay	Apr 15	Jul 17
Nyaungdon	Apr 11	Jul 17
Twante	Apr 15	Jul 17
Kalaywa	Feb 16	Jul 17

Data were provided on:

- Number of vessels
- Total tonnage of vessels
- Revenue receipts

Calculating year-on-year changes in these data (taking account of those months for which data were available in both the earlier and later year), Table 107, Table 108 and Table 125 show year-on-year changes in the number of vessels, tonnages, and revenues by revenue station respectively.

Table 107 - Year-on-year change in number of vessels

(MFR)

	Katha	Mandalay	Monywa	Magway	Pyay	Nyaungdon	Twante	Kalaywa
2011-12						27%		
2012-13						6%		
2013-14						2%		
2014-15						4%		
2015-16			-24%	4%	-6%	-18%	-7%	
2016-17	32%	-23%	-15%	-17%	-7%	36%	-20%	9%

Table 108 - Year-on-year change in tonnage of vessels

(MFR)

	Katha	Mandalay	Monywa	Magway	Pyay	Nyaungdon	Twante	Kalaywa
2011-12						48%		
2012-13						15%		
2013-14						17%		
2014-15						4%		
2015-16			20%	1%	-5%	-11%	30%	
2016-17	70%	-40%	-24%	-25%	-17%	47%	18%	-23%

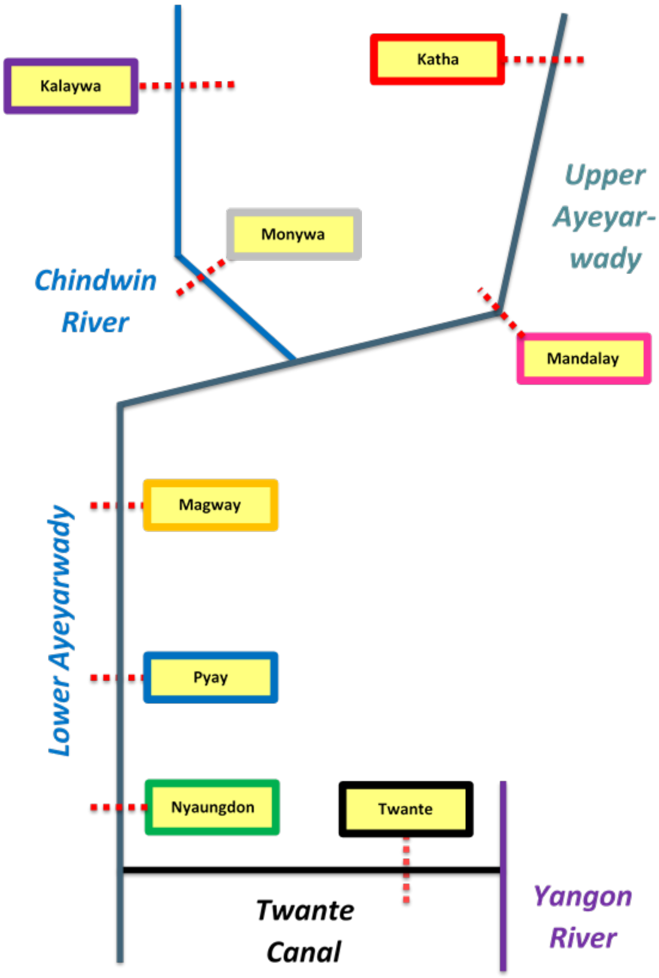


Figure 158 - Schematic of inland waterway traffic data in the Ayeyarwady Basin

Table 109 - Year-on-year change in revenues

(MFR)

	Katha	Mandalay	Monywa	Magway	Pyay	Nyaungdon	Twante	Kalaywa
2011-12						750%		
2012-13						45%		
2013-14						14%		
2014-15						4%		
2015-16			-30%	-21%	-27%	-16%	10%	
2016-17	-29%	-44%	-8%	-25%	-29%	14%	15%	-54%

It can be from these tables seen that patterns are not particularly stable. At the monthly level, the interplay of seasonal variations, longer-term trends and month-on-month noise do not create particularly stable pictures. This is illustrated in Figure 159, with reference to the volatility in tonnages.

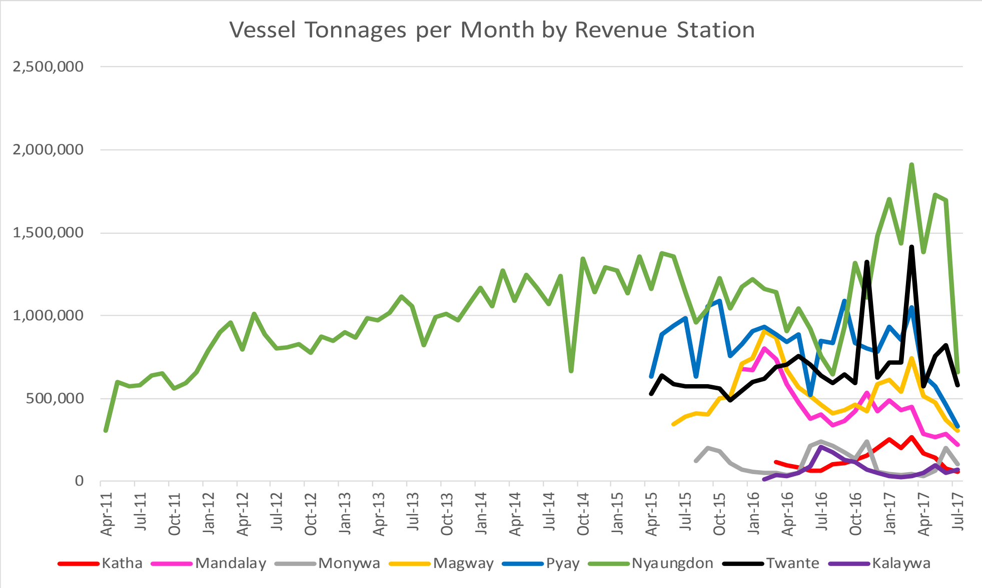


Figure 159 - Monthly changes in vessel tonnages by revenue station

(MFR)

Consequently, data were smoothed on the following basis:

- Taking 50% of the value from the month in question;
- Adding 25% of the value from the preceding month and 25% of the value from the following month; and
- Repeating this process, such that three iterations of such smoothing are conducted.

Applying such smoothing, data are shown as follows:

- Vessel numbers for all revenue stations are shown in Figure 160, with Figure 161showing data only on the Ayeyarwady and Chindwin Rivers;
- Tonnages for all revenue stations are shown in Figure 162, with Figure 163 showing data only on the Ayeyarwady and Chindwin rivers; and
- Revenues for all revenue stations are shown in Figure 164, with Figure 165 showing data only on the Ayeyarwady and Chindwin rivers.

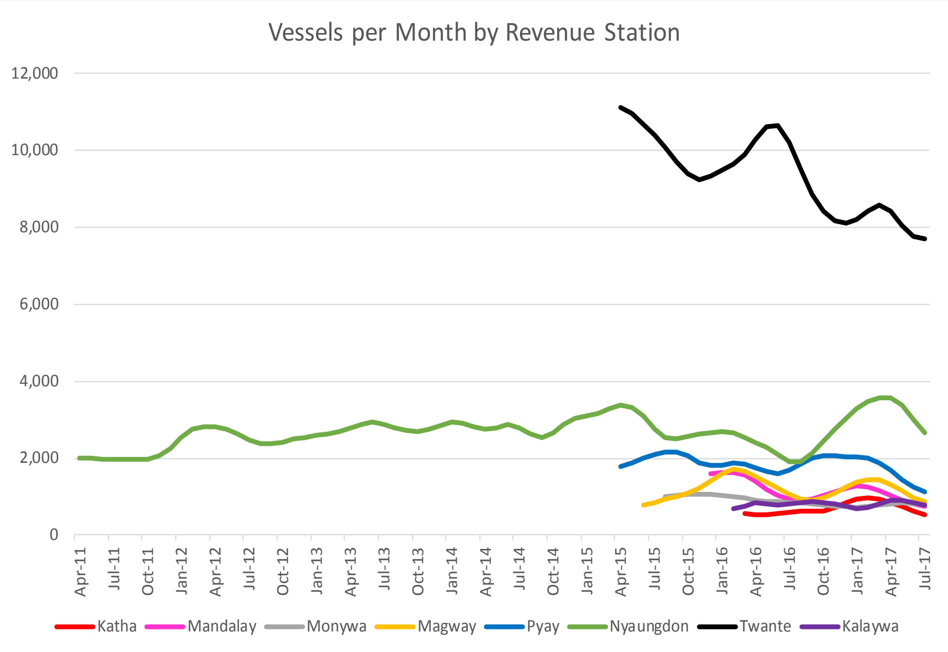


Figure 160 - Monthly changes in vessels by evenue Station – smoothed

(MFR/Study Team)

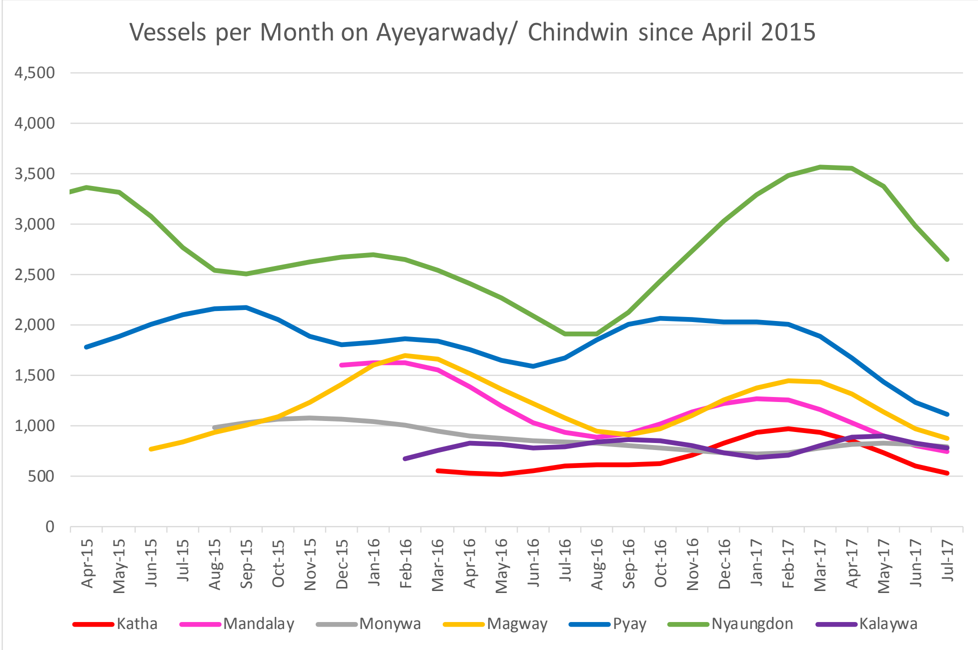


Figure 161 - Vessels by revenue station on Ayeyarwady and Chindwin – smoothed

(MFR/Study Team)

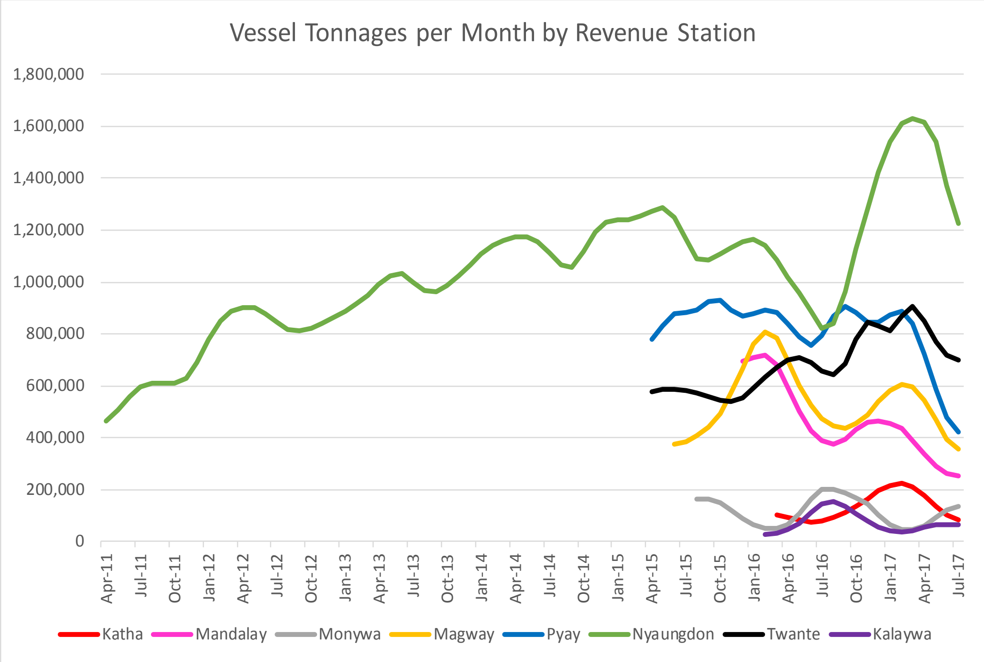


Figure 162 - Monthly changes in tonnages by revenue station - smoothed

(MFR/Study Team)

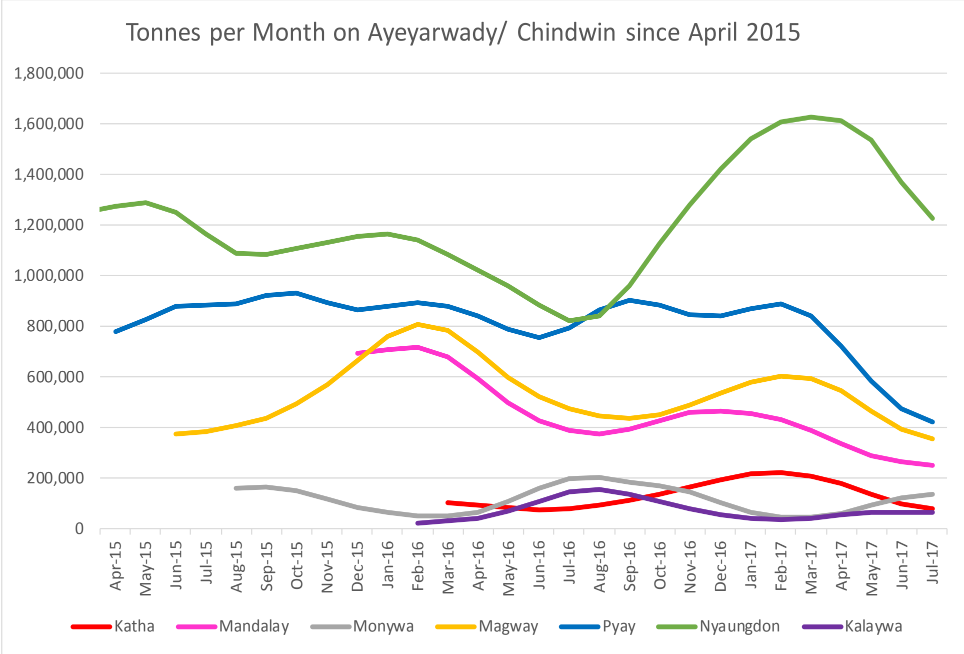


Figure 163 - Tonnages by revenue station on the Ayeyarwady and Chindwin - smoothed

(MFR/Study Team)

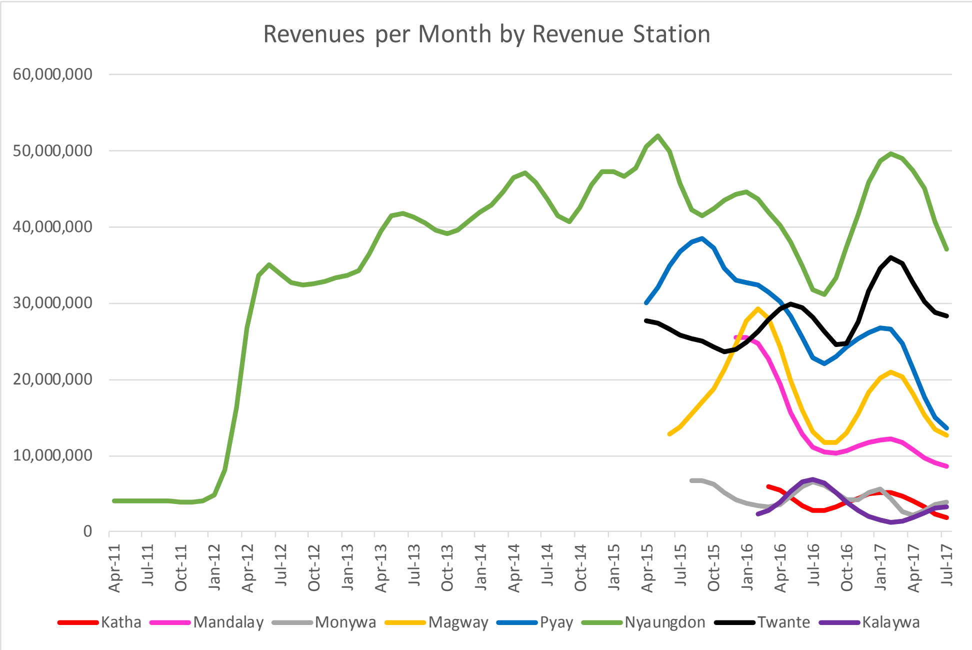


Figure 164 - Monthly changes in revenues by revenue station – smoothed

(MFR/Study Team)

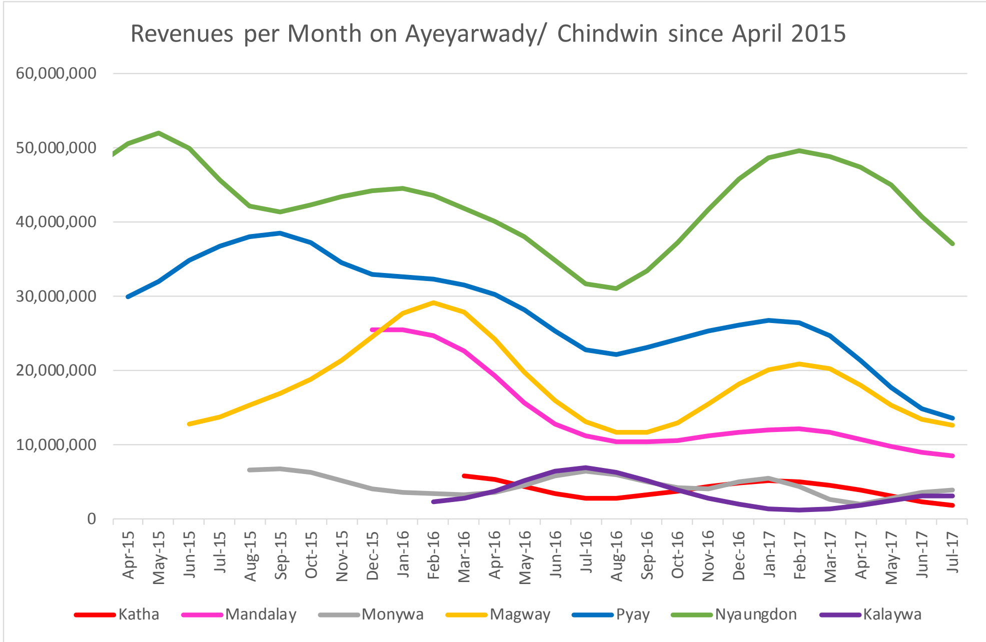


Figure 165 - Revenues by revenue station on the Ayeyarwady and Chindwin – smoothed

(MFR/Study Team

Reviewing Figure 160 to Figure 165, the following can be seen:

- There is still seasonal variation and a certain amount of ‘noise’ in the data
- Vessels, tonnages, and revenue receipts at Nyaungdon (and vessels at Twante) are substantially greater than at other revenue stations.
- In general terms, riparian traffic decreases further upstream
- The longest time-series of data is at Nyaungdon, where there was growth from 2011 reaching an initial peak by approximately April 2015 (vessels, tonnages, and revenues), after which there was a relatively steep decline up until July 2016 (though with oscillation between these dates)
- Since July 2016, traffic through Nyaungdon rose significantly, only to decline again during 2017
- In most cases along the Ayeyarwady and Chindwin rivers, since 2015 there was first growth into early 2016 (Monywa being an exception), but the latest data in July 2017 represent reduced waterway traffic.

Tthese data would tend to support the decline in business evident from comparing Nam & Win (Section 9.2.3) against the JICA Survey Program (Section 9.2.4). And as shall be discussed in Section 9.2.7, such a business downturn has been reported by vessel operators.

9.2.7 *Vessel Operators*

a) Introduction

The Department of Marine Administration is responsible for the inspection and registration of vessels. Initial vessel registration costs kyats 100 per t of vessel capacity.

Subsequent taxes on vessels (including tariffs to use sections of waterway) are collected by township revenue offices, which are under the Ministry of Finance and Revenue. Table 110 shows vessel registrations as reported by DMA’s Mandalay Region. While data on river cruise ships apply nationally, other figures pertain to vessels registered in the Mandalay Region only.

Table 110 - Vessel registrations in Mandalay Region as of 31 August 2017

(DMA, 11 Sept 2017)

Type of vessel	Total registrations	Licence overdue	Valid licence	Under inspection
Cargo Ship	47	30	17	4
Passenger Ship	79	31	48	10
Tug	121	36	85	21
Oil Barge	53	23	30	4
Cargo Barge	52	11	41	12
Boat >20 Horse Power	177	109	68	8
Boat <20 Horse Power	336*			
River Cruise Ships	74**			
Total	939	240	289	59

** Data on Boat <20 Horse Power may be incomplete.*
*** River cruise ships operating along the Ayeyarwady include 3 vessels belonging to IWT and 74 private vessels, of which 21 are registered in Yangon and 53 registered in the Mandalay/broader Ayeyarwady regions.*

Operators of river transport vessels fall into four main categories:

- Small-scale boat operators, described in Section b, such as fishermen, small cross-river ferries and other small vessel operators
- IWT, being the government-run operator of passenger and freight vessels, described in Section c

- Private sector freight vessel owners, who account for the vast majority of freight volumes transported along the Ayeyarwady Basin, described in Section d), and
- Private sector cruise boat operators, described in Section e).

In addition, Section f) presents findings from an interview with an international logistics firm that specialises in maritime transport, but is also involved in logistics arrangements to connect cargoes to the maritime legs of journeys.

b) Small-Scale Boat Operators

The small boats, especially those under 20HP, are typically owned by individuals for personal transport, though some might also be employed as cross-river ferries.

Examples of small boars being used as cross-river ferries at different locations along the Ayeyarwady River are shown in Figure 166 and Figure 167. Figure 168 shows a small (under 20HP) boat being used by fishermen, while Figure 169 shows a small cargo boat in operation along the Ayeyarwady.

Figure 166 - Example of a small vessel in use as a cross-river ferry (1)

(Study Team)

Figure 167 - Example of a small vessel in use as a cross-river ferry (2)

(Study Team)

Figure 168 - Example of a small boat being used for fishing

(Study Team)

Figure 169 - Example of a small cargo vessel in operation

(Study Team)

c) Public Sector - Inland Water Transport

IWT is a government-owned company, under the Ministry of Transport and Communications, which provides a mixture of passenger and freight transport services along the inland and coastal waterways of Myanmar. Operating as a social service, IWT is loss-making. IWT services tend to comprise joint passenger-cargo vessels, serving small communities, rather than just connecting the more major ports.

However, IWT's performance has fallen markedly since a high point in passengers and freight transported during the 2010/11 fiscal year, as shown inTable 111, Figure 170 and Figure 171.

Table 111 - IWT Performance by fiscal year 2007 - 2017 (millions)

(IWT, 2017)

Fiscal year	Passengers transported	Passenger-km	T Transported	T-km
2007/08	26.9	1,153	4.5	931
2008/09	27.4	1,254	4.7	1,023
2009/10	27.1	1,312	4.7	1,100
2010/11	27.6	1,444	4.8	1,206
2011/12	19.3	850	3.4	832
2012/13	15.0	336	2.1	531
2013/14	13.2	234	1.9	453
2014/15	12.3	155	1.8	452
2015/16	11.2	87	1.4	300
2016/17	10.3	72	1.0	176

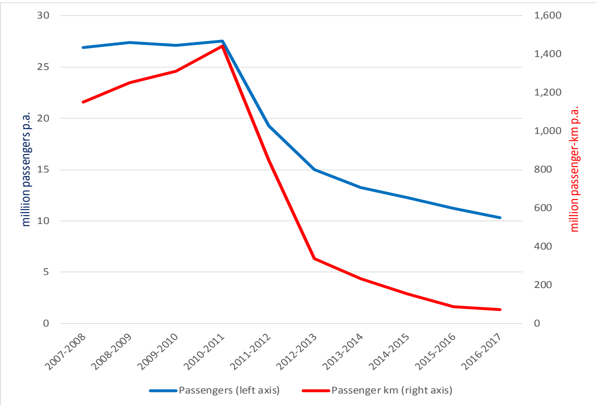


Figure 170 - IWT performance by fiscal year: passenger transport

(IWT, 2017)

Figure 171 - IWT performance by fiscal year: freight transport

(IWT, 2017)

Among the issues faced by IWT are the lack of proper berthing facilities at most points served. For example, on the Mandalay to Nyaung-U route, intermediate stops are made at Myinwe, Mekho, Samealing, Myewdaw, Kengde and Pakokku. However, cargo loading and unloading, as well as passenger boarding and alighting, are achieved by means of plankwalks to connect the vessels to the shore in many instances.

Such arrangements result in significant delays for boarding and alighting of passengers and loading and unloading of cargoes. Typically IWT offers two services a week in either direction between Mandalay and Nyaung-U, using a 'T Line' standard vessel, as shown in Figure 172. Such vessels have a capacity of 182 passengers (six in first class for 4,800 kyats, the remainder at 2,400 kyats; or a foreigner price of 18,000 kyats) and 50 Mt of cargo (charged at 36 kyats per mile per Mt).

Downstream sailings occur on Wednesday and Sunday, usually completed within one day. However, upstream sailings departing on Thursdays and Mondays often have to overnight at Mekho and complete the journey the following day.

Due to navigation issues, during dry season three pilots are employed on the route: Mandalay to Myaung-mu, Myaung-mu to Pakokku and Pakokku to Nyaung-U.

IWT cited other issues in addition to navigation as constraints on their business, such as institutional demarcation, which IWT believes makes addressing the issue of proper berthing facilities more difficult.

Figure 172 - Example of T Class Vessel

(IWT)

d) Private Sector: Freight

Most shipping is performed by the private sector that generally operates dedicated freight vessels. These are typically either barges with push-tugs, as shown in Figure 173 and Figure 174, or self-powered freight ships as shown in Figure 175 and Figure 176.

Figure 173 - Barge with push-tug in operation on the Ayeyarwady River (1)

(Study Team)

Meetings were held with private freight vessel operators both in Yangon (with the Inland Waterway Vessel Owners' Association [IWVOA]) and in Mandalay (with the MBOA).

Points raised by IWVOA in Yangon were as follows:

- They are primarily cargo shippers, though some members operate passenger services between Yangon and the Delta Region. However, passenger numbers have been falling;
- Their 150 members operate approximately 1,000 vessels between them, with capacities in the range 800-1,800 Mt;

- Their members operate services as far north as Kathar. In the wet season only, a few services operate as far north as Bhamo or even Myitkyina;
- Key cargoes to the Chindwin include rice, cement, and other construction materials;
- Rice grown in the Delta Region is also transported to central Myanmar;
- Significant volumes of construction materials are shipped from Yangon to Mandalay and Pakokku. From Pakokku, construction materials are often trucked westwards;
- Previously, significant quantities of timber were shipped from Mandalay to the Delta. However, timber production and trade is now restricted;
- Coal is a two-way trade, with lower grade domestically produced coal shipped south from Mandalay, while higher-grade imported coal (e.g., from Indonesia) is shipped north to Mandalay;
- Coal production around Monywa has been reduced in recent years;
- There is substantial concrete trade from Mandalay and Monywa;
- Gravel is shipped to the Delta from Mandalay and Magway;
- Shipping costs for bulk materials remain cheaper by inland water than by truck, but competitiveness relies on large volumes;
- Government berthing facilities are poor and have not been properly invested in. Consequently, shippers tend to drop anchor wherever they can get trucks to the riverbank for loading or unloading (i.e., bypassing of government facilities);
- All ports were described as 'terrible', but they felt Yangon and Mandalay experience the worst delays;
- In order to cope with dry season conditions, vessels typically sail half-loaded (i.e., they do not have separate vessels for dry season conditions);
- A round trip by ship from Yangon to Mandalay and back can take up to 3 months, given the amount of time required to wait for cargoes on the return trip. In contrast, a round trip by truck can be completed in approximately 6 weeks;
- Loading and unloading delays can amount to eight months per year. Or put another way, there are approximately two days spent loading and unloading for every day's sailing;
- A round trip between Yangon and Mandalay will typically incur approximately 300,000 kyats in river taxes/charges;
- Vessels can sail at up to 7 - 8 knots downstream, but 5 knots upstream.

IWVOA sees the key issues as:

- A need to upgrade vessels for local conditions, i.e., with shallow draft and not too wide;
- Navigation improvements: at present, drafts are too shallow in the dry season, so small propellers have to be used to prevent damage; however, in the wet season the smaller propellers may be insufficient to power against waterflow;
- Proper berthing facilities with proper loading and unloading facilities are required;
- Warehousing facilities should be provided, for instance to enable rice to be stored until prices improve;
- Containerisation is not seen as a priority; a market is not seen for this;
- Handling charges, e.g., loading/unloading charges, are a key constraint on IWT, while road capacities are the constraint on roads.

Figure 174 - Barge with Push-Tug in Operation on the Ayeyarwady River (2)

(Study Team)

IWVOA gave cost indications for transporting one Mt of rice from Yangon to Mandalay as follows:

- By ship: 20 - 25,000 kyats in the dry season, plus approximately 3,000 kyats for loading and unloading
- By ship: 8,000 kyats in the wet season, plus approximately 3,000 kyats for loading and unloading
- By road: approximately 30,000 kyats in the dry season. Or 25,000 kyats in the wet season. The cost premium in the dry season for road (when road conditions are better) is due to demand.

Key points raised by MBOA in Mandalay were as follows:

- MBOA has 51 members operating approximately 100 vessels in total. The largest operators control approximately 20 vessels, but there are many with just a single vessel
- Wet season carrying capacity is up to 1,500 Mt, but this reduces to 700 - 800 Mt in the dry season
- The largest vessels are 200' long, 50' wide and 10' high (from keel to bridge)
- Vessels operate at approximately 5 knots and can sail for approximately 10 hours a day (due to nighttime restrictions, navigation issues, etc.)
- The lack of good berthing facilities means that operators typically drop anchor where trucks can come right up to the shoreline for direct cargo transfer from vessel to truck and vice versa
- Such loading and unloading typically requires 2 - 3 days (2 days for 700 Mt; 3 days for 1,500 Mt). However, cement and sugar can take approximately 7 days
- However, vessels can wait up to one month for cargoes to load
- Demand has fallen considerably since restrictions on mining and logging have been implemented
- There used to be good business shipping rice and sugar from Yangon or the Delta to Mandalay, for onward trucking to China (via Muse/Ruili), but this business is susceptible to changing policy by Yunnan Province
- Southbound trade from Mandalay is often gravel or cement
- MBOA members complained that DMA has recently mandated that specific barges be used for the transport of oil. Previously members could use the same barge to transport general cargo south, then oil and related products north
- MBOA members reported that business was last good in 2014, but has got noticeably worse since, with a 30% decrease in profits by 2015/16. Businesses are currently struggling to break even. Some

members stated that they can remain in business for perhaps two more years, after which they will need to withdraw if business conditions do not improve

MBOA expressed their priorities for improvement as follows:

- First priority is dredging, so that vessels can operate at their full 1,500 Mt capacity year-round
- Second priority would be the navigation aid improvements, so that they could operate for more than 10 hours per day
- Third priority would be to have proper berthing and loading/unloading facilities, to reduce time in port and loading/unloading costs
- Warehouses might be useful if business improves. But under current conditions, ship charterers insist on using vessels/barges as floating warehouses that they also refuse to pay for (as previously reported, if the vessel owners attempt to charge for demurrage or such storage, they risk losing business). So warehouses are not seen as a priority
- MBOA members do not see the worth in containerisation. They require business to improve.

Figure 175 - Ship Sailing on Ayeyarwady River (1)

(Study Team)

Figure 176 - Ship Sailing on Ayeyarwady River (2)

(Study Team)

e) Private Sector: Passengers (Cruise Ships)

Private sector-led passenger services along the Ayeyarwady generally comprise either cross-river ferries, as described previously in Section b, or passenger cruises primarily for foreign tourists. The private sector does not get involved to any substantial extent in passenger transport along the Ayeyarwady, other than for tourism purposes.

The key points raised when the Consultants met with the Cruise Boat Owners' Association (CBOA) in Mandalay, were as follows:

- Services vary greatly according to season, with the dry season being their peak season
- From July to early November there are relatively few sailings. Typically a daily or near-daily service in either direction between Mandalay and Nyaung-U
- During the November to March peak season, services include:
  - Mandalay - Nyaung-U (multiple daily)
  - Mandalay - Bhamo (taking 4 days/3 nights, with stops at Katha and Kyaukmyaung)
  - Mandalay - Kyaukmyaung
  - Mandalay - Pyay (6 days/5 nights)
  - Mandalay - Monywa
  - Mandalay - Kakwa
  - Mandalay - Khamti - Mawlamyine (10 days/9 night)
- During peak season there are typically 400 cruise passengers transported per day

- 52 ships operate in this business, with 42 being under ownership of members of CBOA
- The largest vessel with sleeper capacity can sleep 29 passengers and is 98' long, 22' wide with a depth of 6'
- The largest capacity of a non-sleeper can take 70 passengers
- Two or three new vessels join the business every year
- There are six foreign operators, who lease eight vessels from IWT
- In the dry season, due to waterways shifting, services are slower and vessels often need to take less direct routes so as to avoid grounding

Figure 177 and Figure 178 show cruise ships anchored during the low season in Mandalay and Nyaung-U respectively. Figure 179 shows two smaller passenger cruise ships, one of which was in active use. Figure 180 shows a passenger cruise ship with cabins for overnight journeys in operation.

Figure 177 - Passenger cruise vessels anchored in Mandalay during low season

(Study Team)

Figure 178 - Passenger cruise vessel with sleeping compartments anchored at Nyaung-U

(Study Team)

Figure 179 - Smaller capacity passenger cruise ships; one on left in active operation

(Study Team)

Figure 180 - Larger passenger cruiser with cabins operating in low season

(Study Team)

f) Views of an International Logistics Firm

While not a vessel operator per se, a meeting was held with Damco (formerly Maersk Logistics), an international logistics firm primarily in the shipping industry (but who also arrange logistics to connect to and from maritime transport legs, as appropriate). Key points raised included the following:

- Damco's business is currently 100% export-oriented.

- Damco ship typically 10 - 20 containers per day.
- Industry has been developing fairly rapidly in Yangon in recent years.
- Typical factories (e.g., in garments) employ approximately 1,000 - 1,200 workers.
- It is estimated that approximately 95% of these are owned by mainland Chinese or Taiwanese firms.
- These are mainly located on the outskirts of Yangon, around Shwepyithar (to the north of the east end of the Twante canal).
- Shipments by container typically proceed to Malaysia or Singapore (or to a lesser extent, Colombo), where they are often re-consolidated with some containers being simply trans-shipped there for onward embarkation to Europe or North America.
- 1,200 TEU is the largest vessel size now operating, though there is scope for 1,600 TEU vessels in the future.
- However, traffic congestion, power, and water supply issues are constraining the further growth of manufacturing in the Yangon area, as well as increasing land costs. At present a 6am to 11am and a 3pm to 9pm truck ban is in force in Yangon.
- Further growth will require the development of additional manufacturing hubs, with plentiful power and water supply having been identified as supporting the future development of manufacturing around Mandalay, but this is currently hampered by a lack of containerised shipping facilities. The JICA-proposed Mandalay container terminal would overcome this.
- There is also a green theme to IWT, with Nike in particular prepared to incur an extra day's shipping time in order to reduce truck miles and divert onto IWT.

As such, Damco were very supportive of proposals to boost containerised traffic on Maynmar's inland waterways and to develop Mandalay as a new hub of industry and employment.

9.2.8 *Rail Transport*

The Consultants met with Myanmar Railways in Nay Pyi Taw. Key points raised include the following:

- Passenger services are run at a loss, with fares set as shown in Table 112. Passenger services are deemed a social service.
- Freight services run at a profit, albeit insufficient to offset losses from passenger services. Freight tariffs are as per
- Table 113.
- Freight trains are generally full, or close to full, when running from south to north, but are often empty when travelling from north to south; hence the differences in directional tariffs as shown in
- Table 113.
- Operating data (passengers and freight carried) and revenues for the 2016 - 2017 fiscal year are shown in Table 114.

Table 112 - Railway passenger fares

(Myanmar Railways)

Terrain	Class	Fare (kyats per passenger per mile)	
		Express train	Local train
Flat land	Ordinary class	12	9
Hills	Ordinary class	18	13.5
Flat land	Upper class - seat	24	21
Hills	Upper class - seat	36	31.5
Flat land	Upper class - sleeper	33	27
Hills	Upper class - sleeper	49.5	40.5

Table 113 - Railway freight tariffs

(Myanmar Railways)

Terrain	Tariff (kyats per t per mile)	
	Uphill (northbound)	Downhill (southbound)
Flat land	30	20
Hills	45	35

Table 114 - Myanmar Railways operating data in Mandalay, Yangon, and Pakokku Divisions, 2016 - 2017 Fiscal Year

(Myanmar Railways)

Division	Passengers carried (millions)	Fares revenue (million kyats)	Freight carried (million t)	Freight revenues (million kyats)
Mandalay	2.044	6,735.614	0.378	3,404.457
Yangon	2.429	5,526.139	0.588	8,747.516
Pakokku	0.461	188.058	0.077	0
Total of the above	4.939	12,449.811	0.977	12,152.013

As with IWT, railways are typically argued to benefit from lower marginal costs of transport than road. However, as with inland water, railway network expansion costs tend to be more 'stepped' than those for road. Inland waterway port investments are quite substantial fixed costs, whereas for rail, it is typically the expansion of railway tracks that entails substantial upfront costs.

The key challenges for rail, given that freight services are at or near capacity northbound while being near empty southbound, would be to improve utilization of southbound freight services. As without such business, it may be difficult to justify the expansion of network capacity (i.e., new track) northbound.

9.2.9 *Road Transport*

As previously shown in Section 9.2.4, road transport enjoys a dominant market share for both passengers and freight.

Nam & Win report that Myanmar's road network doubled in extent between 2001 and 2012, growing from 69,732 km to 146,689 km. Of this, Union highway (national standard roads) account for 13%. Moreover, the expansion of the road network was coupled with the development of highway bridges. Indeed, the development of road bridges to replace ferry services has likely been critical to the growth of road transport. The cross-river ferries replaced would have been limited to daytime-only operation. Furthermore, each ferry would previously have added significant delays to road journeys, given the width of many rivers.

More recently, the liberalisation of regulations governing the import of second-hand vehicles has provided further impetus to the development of the road transport sector. While roads, like waterways and rail, have suffered from underinvestment, network rehabilitation and upgrading has been assisted by the implementation of toll facilities from which a proportion of proceeds are invested back into road maintenance, repair, and upgrade. Figure 181 shows a small, heavily laden truck at the tollgate for the Ava Bridge. Figure 180 shows another view of this heavily laden truck.

As such, it is likely that road freight's mode share is likely to only increase in coming years. Lead-times for upgrading road transport infrastructure are often shorter than those for waterway or rail, especially given that river and rail infrastructure upgrades tend to require larger units of investment. That being said, there will likely be a certain point at which the road network becomes saturated, at which point it will require substantial upgrades (e.g., new highways).

Figure 181 - Example of a small truck carrying sacks of cargo at a toll station for the Ava Bridge

Figure 182 - Example of a small truck carrying sacks of cargo near Ava Bridge

It would be extremely imprudent to rely upon road transport alone to address increased transport demands in Myanmar. As shown by Nam & Win, road transport tends not to be as cheap as barging can be (also refer to Figure 140).

9.3 Summary of Findings

9.3.1 *Key Themes*

Years of underinvestment have affected all modes of transport in Myanmar. While these issues are now starting to be addressed, it should be noted that different modes can respond at different speeds. For example:

- River transport requires improved navigation and ports facilities, while vessel owners also have to adjust to changes in demand, including *inter alia* tightening restrictions on logging and mining industries, which have decreased demand more than newer segments have been growing.
- Rail infrastructure is costly and time-consuming to upgrade, with northbound freight trains reported to be operating at near-capacity, while southbound trains are reportedly often largely empty.
- Road transport, on the other hand, especially following liberalisation of regulations on importing second-hand vehicles from overseas (e.g., Japan), has seen road traffic levels grow much more rapidly than those of other modes.

Although there are issues with the availability, consistency, and, by implication, robustness of many of the data which are available, both quantitative data and findings from qualitative interviews with stakeholders would nevertheless support the above key themes.

9.3.2 *Summary of Key Findings from Stakeholder Interviews*

There were some disagreements between stakeholders. For example, private freight vessel operators appeared disinterested in containerisation, whereas DWIR and the International Logistics Firm saw containerisation as a necessity to enable a stepwise improvement in river transport.

Nevertheless, key findings can be summarised as follows:

1) There appears to have been substantial growth in road freight transport in recent years, which might be set to continue, given ongoing improvements in the road network. However, capacity bottlenecks may yet arise or, in the case of Yangon, worsen.
2) Rail freight northbound has also seen strong demand, but capacity constraints are already being felt (many trains are already full), whereas there is spare capacity southbound.
3) Significant reductions in waterborne freight transport have been reported. Besides growth in road transport, this was attributed by ship owners to restrictions placed on the mining and logging

industries, in particular, with the China import-export trade (via Mandalay Port then trucking to Muse) being susceptible to policy changes by Yunnan Province or the Chinese Central Government.

4) The potential for water transport is currently constrained by a number of factors:

- A backlog of dredging works that has resulted in the upper reaches of the Ayeyarwady and Chindwin Rivers being non-navigable in the dry season and restricting draft and increasing sailing times -in other sections of the rivers.
- A lack of properly maintained, modern navigation aids, which curtails the sailing day to approximately 10 hours.
- Slow loading and unloading times due to poor facilities at berths. As a consequence of these, private operators often load and unload at informal anchoring points. Manual loading and unloading adds time and expense to shipping operations, and informal anchoring may also have environmental consequences.

5) Other constraints on water transport, which are perhaps secondary at the current time, that will likely become significant on a rebound in the river shipping industry, include the following:

- A lack of proper warehousing facilities. At present, ship charterers use vessels as free warehousing facilities. However, on business recovery, not only might they no longer be able to do this, but storage of cargoes on unsheltered land would pose risks to cargoes, especially perishable ones.
- The shipping fleet was reported to be old and, hence, likely inefficient and more environmentally damaging than newer, more efficient vessels. However, upgrading is not seen as an immediate priority given the current business climate.
- Containerisation could trigger the development of new industrial areas along the Ayeyarwady Basin, especially given the capacity constraints already being felt in Yangon (e.g., traffic congestion, land prices, water, and electricity supply issues).
- Freight handling charges, including for containers, are currently seen as prohibitively expensive by vessel operators (private and IWT alike). This point is perhaps best made under the earlier list of current constraints. However, overcoming it may require the kind of economies of scale on which IWT is itself predicated (i.e., as containerisation develops, competition and better utilization of facilities might result in reduced handling charges). Note, however, that such price reductions are not guaranteed, but rather efforts should be made to ensure that prices become more reasonable or more justifiable (i.e., if such charges become more economically viable as the opportunity cost of long loading and unloading times becomes such that containerisation can be justified).

6) As such, the initiatives being investigated by DWIR would appear timely, comprising the following:

- A potential US$ 100 million loan from the World Bank to accelerate dredging of the Ayeyarwady River.
- US$ 1.6 million of support from the Belgian Government to upgrade navigation aids.
- JICA assistance to upgrade a number of ports along the Ayeyarwady and Chindwin Rivers.
- JICA proposals to develop Mandalay Port, including container facilities.
- DWIR initiatives to explore other container facilities.

9.3.3 Cost Comparisons

International data (e.g., Figure 140) suggest that IWT ought to be more cost effective than either road or rail transport.

Nam and Win (2014) (Section 9.2.3) demonstrated that IWT should be more cost effective than road transport. However, their analysis assumed 75% utilization of shipping capacity, whereas interviews with private shipowners would suggest that such utilization rates are not achieved at the current time. Moreover, 10 round trips per annum are not currently attained per vessel, as there are substantial periods spent awaiting cargoes.

Furthermore, cost comparisons between road and IWT, between MITT and Shwepyithar, suggest that road transport enjoys certain cost advantages and journey time advantages on some routes.

While these discrepancies in findings might be due, in part, to changing circumstances since the period analysed by Nam and Win (2014), the scale of discrepancies suggest that further study of actual costs and times should be undertaken, as is recommended in Section 9.3.6.

9.3.4 Demand Trends and the Demand Dilemma

Sections 9.2.3, 9.2.4, and 9.2.6 each present historical, current, and future data for IWT. As noted already, there were a range of inconsistencies between these datasets, which could not be wholly explained away simply on the basis of when each set of analyses was prepared.

Nevertheless, a pattern can still be discerned which was borne out by findings from interviews with private shipowners and government-run IWT. The general pattern can be summarised as thus:

- Within the last few years, there has been growth in export-oriented manufacturing around Yangon, but this has not spread further upcountry.
- Political change and the accompanying economic and trade liberalisation have resulted in more maritime shipping volumes, including among other things, import of second-hand road vehicles. This increased maritime trade has, for the most part, not been exhibited in the Upper Ayeyarwady.
- Conversely, under the new regime, environmental and social protections more closely aligned with international norms, than was previously the case, have been applied. These environmental and social protections have resulted in a marked downturn in the mining and logging industries, both of which were previously drivers of demand for IWT.
- While it is likely that political, economic, and trade developments will, over time, facilitate new areas of economic growth that will, in turn, provide new opportunities for riparian shipping, such new growth drivers will take time to develop.
- In the meantime, riparian shipping will likely continue to suffer from reduced volumes, as compared to the situation of a few years ago.
- As a consequence of low demand, riparian shipping will continue to suffer in the near-term from over-capacity, which itself is a strong deterrent to investment.

It is further noted that there is a strategy being developed to promote industry in central Myanmar, in particular around Mandalay. Some of the drivers for this emanate from Yangon, where land prices and land availability as well as access to electricity and traffic congestion are starting to act as constraints on the future growth of export-oriented manufacturing there.

However, while these factors suggest that IWT could enjoy a renaissance in Myanmar, it is also the case that such a renaissance is not guaranteed. Furthermore, the timing of any such recovery is inherently uncertain.

This serves to create a demand dilemma. Without upgrading IWT, its future is almost certainly bleak. However, even with such upgrades, the timing of the renaissance of IWT remains highly uncertain, and, in fact, is not guaranteed.

As such, from a strategic perspective, upgrading IWT (i.e., over and above maintaining a status quo or marginal improvements) is desirable. However, it is also inherently very ‘risky.’

9.3.5 Appropriateness of Proposed Interventions to Address Issues Identified

a) Introduction

As stated in Section 9.1.2, detailed evaluation of proposed interventions is beyond the scope of this baseline analysis. Furthermore, discrepancies noted in both cost data and demand data mean that more research would be necessary in order to properly evaluate the interventions proposed.

Nevertheless, some commentary on these proposed measures would be appropriate and, as such, is presented as follows.

b) Updated charting of rivers

Section c described initiatives by DWIR and supported by foreign aid to re-chart river depths and channels.

This exercise is deemed necessary to reconcile currently incomplete and conflicting data on river depths. Indeed, such works are also necessary to inform priorities for dredging (see 9.3.5 c).

As such, initiatives to update river charts are fully supported.

c) Navigation aids and dredging

Although navigation aids and dredging constitute two different programmes of interventions, their impacts would work together in practice. They enable vessels to carry heavier loads during the dry season and improve year-round navigation conditions that could potentially enable night-time sailing.

Such night-time sailing would enable better utilization of vessels, as they would spend less unproductive time with dropped anchor, and would reduce journey times.

Therefore, in principal, such measures would be supported, all other things being equal. Given the many years of underinvestment in transport infrastructure in Myanmar, it would seem likely that some dredging would be economically advantageous.

However, it is beyond the scope of this assignment to determine how much dredging should be undertaken, when, and where. In addition, currently, there are insufficient data to enable full economic analysis of this question.

d) Port development for general cargo handling

It is noted that IWT and private shipowners support proposals to improve facilities for handling general cargo across the Ayeyarwady Basin. As noted in this chapter, there appears to be scope for significant improvements in facilities and, hence, turnaround times at ports.

As such, further investigation of these interventions would be supported.

As with dredging, however, it is beyond the scope of this assignment to determine either the economically optimum extent of improvement of general cargo facilities or the most beneficial locations to make improvements. Based upon volumes handled, it appears that Mandalay Port has the most potential for economic benefits from improvement works.

e) Containerisation: Mandalay Port container terminal

At present there are no facilities in the Upper Ayeyarwady to handle containers transported by inland waterway. As such, even had IWT been experiencing steady trends in growth, it would still not be straightforward to predict the likely uptake of container facilities, let alone perform economic cost-benefit analysis on proposals for containerisation.

While containerisation might well enable IWT to achieve improved cost efficiencies over time, a number of challenges remain. These include the following:

- The current environment of reduced demand and, hence, over-capacity in the IWT industry, which serves as a strong deterrent to fresh private investment into the sector; and

- The successful development of containerisation requires a critical mass of ports supporting containerised cargos.

It is conceivable that the critical mass of container-capable ports could comprise Mandalay, MITT, and Shwepyithar in the first instance. However, this would require the development of sufficient demands between these ports, with export-oriented manufacturing likely being a key component.

Should containerisation at Mandalay Port succeed (with general cargo business continuing alongside), then this could provide an impetus to implement further conatinerisation for other cargoes and at other ports.

It is likely that the JICA support, as donor aid, will be critical for these plans to proceed, as they would likely be too risky for private sector involvement at this time.

Another issue to be considered is the pricing strategies for container loading and unloading, given complaints from IWT and private shipowners regarding the costs of container handling at MITT.

9.3.6 Recommendations for Further Works

This chapter has shown that there are inconsistencies in estimates of transport demands by mode and gaps in data. It also shows that similar issues appear to be present when considering transport costs by various modes.

A number of proposed interventions, such as re-charting river depths and the improvement of navigational aids, do not require substantial further feasibility exercises. For example, a further feasibility study of navigational aids at US$ 1.6 million would add significant percentages to the total project cost, while also delaying implementation. In so doing, it would also postpone the accrual of benefits.

Likewise, initial dredging plans, in terms of target dry season depths, can also proceed, as the intention is to dredge along the Ayeyarwady Basin to achieve a gradual increase in dry season river depths. Once again, further study would yield further delay and, hence, deferment of benefits.

Larger proposed interventions (i.e., determining the extent and location of dredging in the long term) and port upgrading works (i.e., determining which ports are to be upgraded to what standards and when) potentially entail significantly more capital expenditure. Added to which, project lead times would allow for further study to optimise investments. In other words, the opportunity cost of proper evaluation would not be significant, yet the scope to increase investment returns through optimising investment and schedules could be substantial.

The JICA Survey Program developed a Union-wide transport model, but, as discussed in Section 9.2.4, that study appeared to contain a number of anomalies. Furthermore, using 71 zones to cover the entire Union, does not allow sufficient detail to assess the relative merits of upgrading different river ports along the Ayeyarwady or Chindwin Rivers.

As such, it is recommended that the following be undertaken, covering the entire Ayeyarwady Basin, including the Twante Canal and Yangon River:

- A comprehensive programme of transport surveys, covering costs and demands for all modes.
- Investigation of linkages between modes to assess where and how they could be complementary, as opposed to simply competing.
- Development of a comprehensive, multi-modal transport model, calibrated to current conditions and capable of being used to forecast and test possible future scenarios, both for demand forecasting purposes and to facilitate economic analysis of schemes, including alternatives analysis.
- Such an exercise would necessarily entail the engagement of foreign consultants but could also be used as an opportunity to develop capability within Myanmar.

10 URBAN DEVELOPMENT AND MANUFACTURING

10.1 Introduction

This section deals with the urban system in the Ayeyarwady Basin, and closely related to this, the development of manufacturing industry and IZs.

10.2 Urban Development

10.2.1 *Urban Development Sector in Ayeyarwady Basin*

a) Urban population

Myanmar's 2014 population and housing census shows that 32.5% of the total population in the Ayeyarwady Basin live in urban centres (cities and towns). This is approximately 11 million of the approximately 33 million people living in the Ayeyarwady Basin (UNFPA 2014). The largest cities in the Ayeyarwady Basin, Yangon (population 4.9 million), and Mandalay City (population 1.4 million) account for 56% of this urban population. Most of the 168 urban centres throughout the Ayeyarwady Basin are relatively small, and only 10 urban centres have over 100,000 inhabitants. There are 116 urban centres with a population of 25,000 or less, and 50 with fewer than 10,000 people.

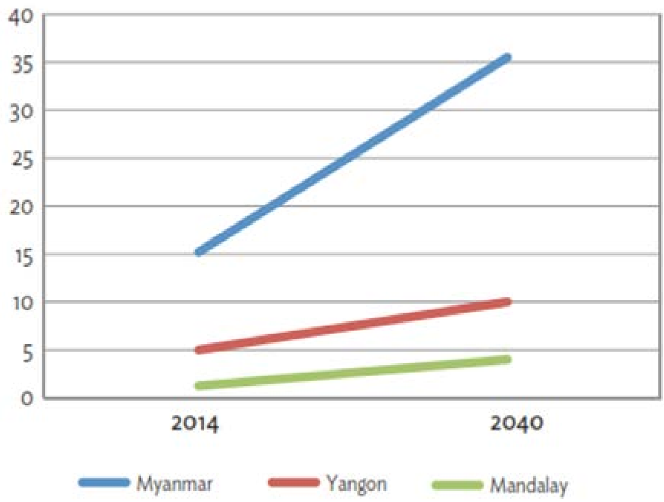


Figure 183 - Projected urban population growth, 2014 - 2040

For many years, the level of urbanization in Myanmar changed slowly, from 19.2% of the total population in 1960 to 34.7% in 2016. The Ministry of Construction's Department of Housing and Urban Development (DHUD), forecasts a strong increase in the urbanization rate in the coming decades. By 2040, it is projected that some 50% of Myanmar's total population will be living in urban areas (Figure 183). Yangon and Mandalay will increase steadily, while other urban centres are expected to increase far more rapidly. With the country's two largest urban centres that drive the rapidly expanding economy located in the Ayeyarwady Basin, the basin and its resources will see significant impacts due to increased urbanization in the future.

Outside of the major centres of Yangon and Mandalay, levels of urban development have been limited. Livability indicators in almost all Ayeyarwady Basin urban centres are currently below international and many regional indicators. Economic and health indicators are also at low levels.

b) Population growth

Urban centres can be both productive and liveable. The benefits of cities can depend on their scale - greater concentrations of people create more frequent economic and social interactions, which boost productivity and offer a higher quality of life. However, such consequences are only the result of urban areas that are well planned, serviced, and regulated.

The government is planning to change the present rural nature of Myanmar's demographics, where only approximately one-third of the population is currently living in urban areas. The government has proposed rapid change, with projections of increased urbanization and far greater populations in the Ayeyarwady Basin by 2040 (Figure 184).

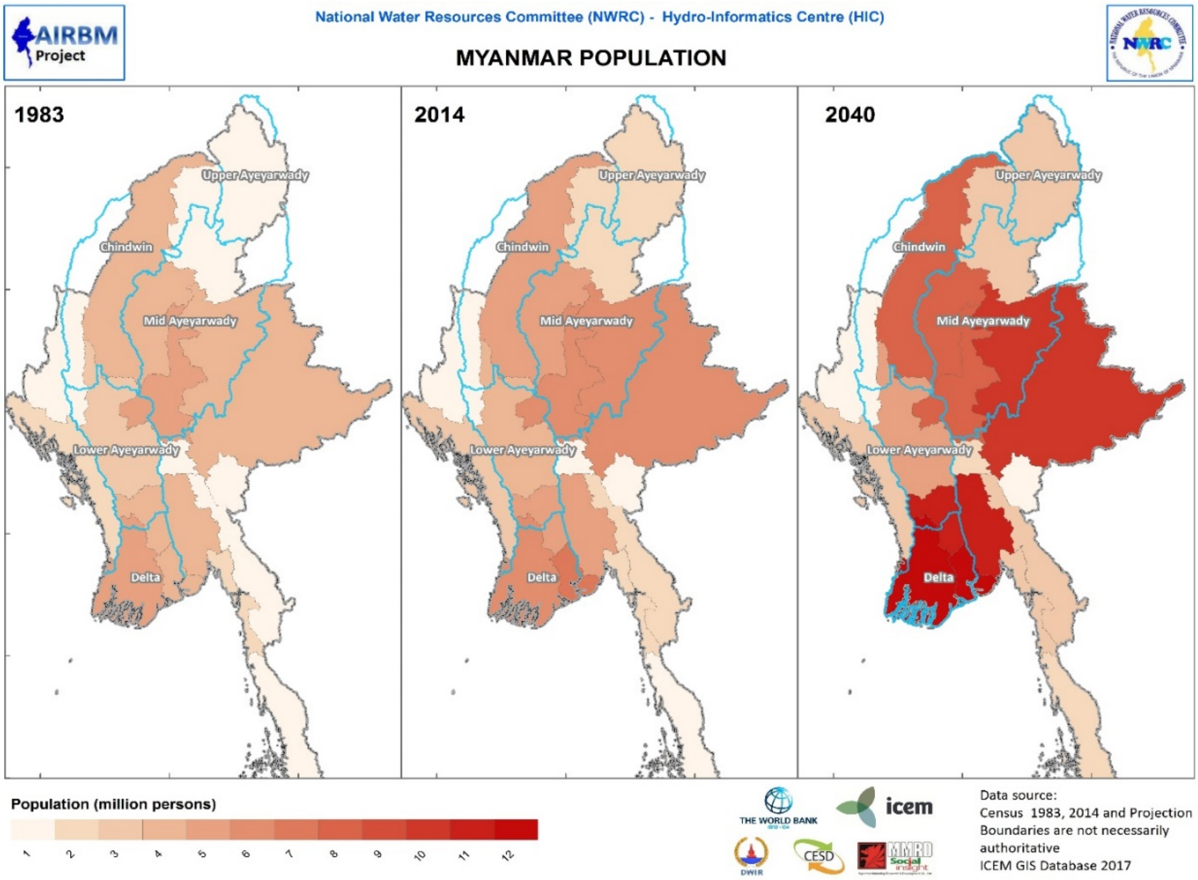


Figure 184 - Population growth in Myanmar - Government of Myanmar projections

10.2.2 *Historical and Socioeconomic Performance*

A high proportion of Myanmar and the Ayeyarwady Basin's population have historically been based in rural areas, a significant characteristic of the country that has been slow to change, especially in comparison to countries nearby (Figure 185). Due to this historic, predominantly rural population base, investment in the urban development sector has been limited until recently.

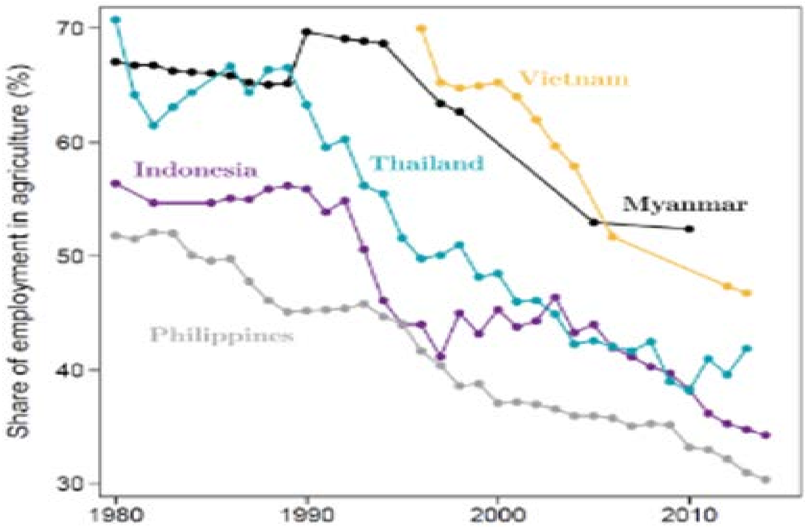


Figure 185 - Employment in agricultural sector selected SE Asian countries 1980 - 2016

As a result, the Ayeyarwady Basin urban development sector has experienced limited urban planning, and is characterised by inadequate urban infrastructure and services. Policies and laws for land management, environmental protection, water resource management, decentralisation, housing development, and urban planning and development are still limited. Furthermore, there is a need to strengthen planning coordination between government agencies and improve the understanding of the division of roles and responsibilities at central, regional, state, and municipal levels of government. Currently, the poor linkages across national development plans, spatial plans, and sector master plans compound the constraints that limit the socioeconomic performance of the urban development sector.

The government is now focusing on substantial improvements to the urban development sector through infrastructure investment for both Yangon and Mandalay. Concurrently, the government has established a number of IZs close to strategic urban centres aimed at accelerating economic and urban development growth (see Section 10.4).

The socioeconomic performance of a number of the urban centres in Ayeyarwady Basin states and regions continues to be impacted by migration. This is a major issue in Yangon and Mandalay regions where economic activity demands high amounts of unskilled labour. The emerging need for rural households to diversify their income sources, and the government's increased investment in schools and local urban infrastructure are resulting in labour shortages in smaller cities and towns that are a common feature of the Ayeyarwady Basin.

10.3 Urban Centres and Development Trends

10.3.1 Background - Urban Areas

A four-level hierarchical classification is used by the government to indicate the importance of urban cities and towns in Myanmar. The DHUD of the Ministry of Construction uses a different seven-level classification for urban centres based on their population. A summary of the classification for Ayeyarwady Basin urban centres is provided in Table 115.

Table 115 - Classification of urban centres in Myanmar

Government Classification	Ayeyarwady Basin urban centres	DHUD Classification (by population)	Ayeyarwady Basin urban centres
City hierarchy		>1,000,000	2
Primary	2	300,000 <1,000,000	0
Secondary	6	200,000 - <300,000	2
Tertiary	9	100,000 - <200,000	6
Special Purpose	2	50,000 - <100,000	17
-	-	25 - <50,000	25
-	-	<25,000	116

10.3.2 Major Urban Areas (population >1,000,000)

The urban development sector of Myanmar and the Ayeyarwady Basin is dominated by the Yangon and Mandalay urban centres, their large IZs, and their surrounding, well-populated rural areas. These large cities are the only urban centres in the Ayeyarwady Basin to exhibit high population densities, above 15,000 persons/km^2 (see Annex III).

In Yangon, which had a population of 4.8 million in 2014, 30 of the 39 townships that make up the nation's largest city/region have a high population density designation. Mandalay, with a population of 1.4 million in 2014, has a high population density designation only in 5 of the 27 townships comprising the nation's second largest city/region. Both Yangon and Mandalay have national hierarchical classifications of primary city.

10.3.3 Large Urban Areas (population 200,000 to <1,000,000)

In the Ayeyarwady Basin, only two urban centres fall into this category; Monywa in Sagaing Region and Myitkyina in Kachin State, with 2014 populations of 207,489 and 246,506, respectively. Both urban centres have very low population densities but these figures may reflect that relatively large rural areas are also included within the boundaries of these townships. Myitkyina has a national hierarchy classification of 'secondary' while Monywa has a 'tertiary' classification. The locations of these cities are shown in Figure 173.

10.3.4 Upper Medium Urban Areas (population 100,000 to <200,000)

Six Ayeyarwady Basin urban centres fall into this category. Their details are provided in Table 116, and the locations of these cities are shown below, in Figure 186.

Table 116 - Details of Ayeyarwady Basin Upper Medium Urban Centres

Urban centre/state or region	Population (2014)	Hierarchy classification
Kalewa/Sagaing Region	130,506	
Lashio/Shan State	174,335	Tertiary
Meiktila/Mandalay Region	111,522	Tertiary
Pathein/Ayeyarwady Region	187,442	Secondary
Pyay/Bago Region	134,861	Tertiary
Pyinoolwin/Mandalay Region	158,783	

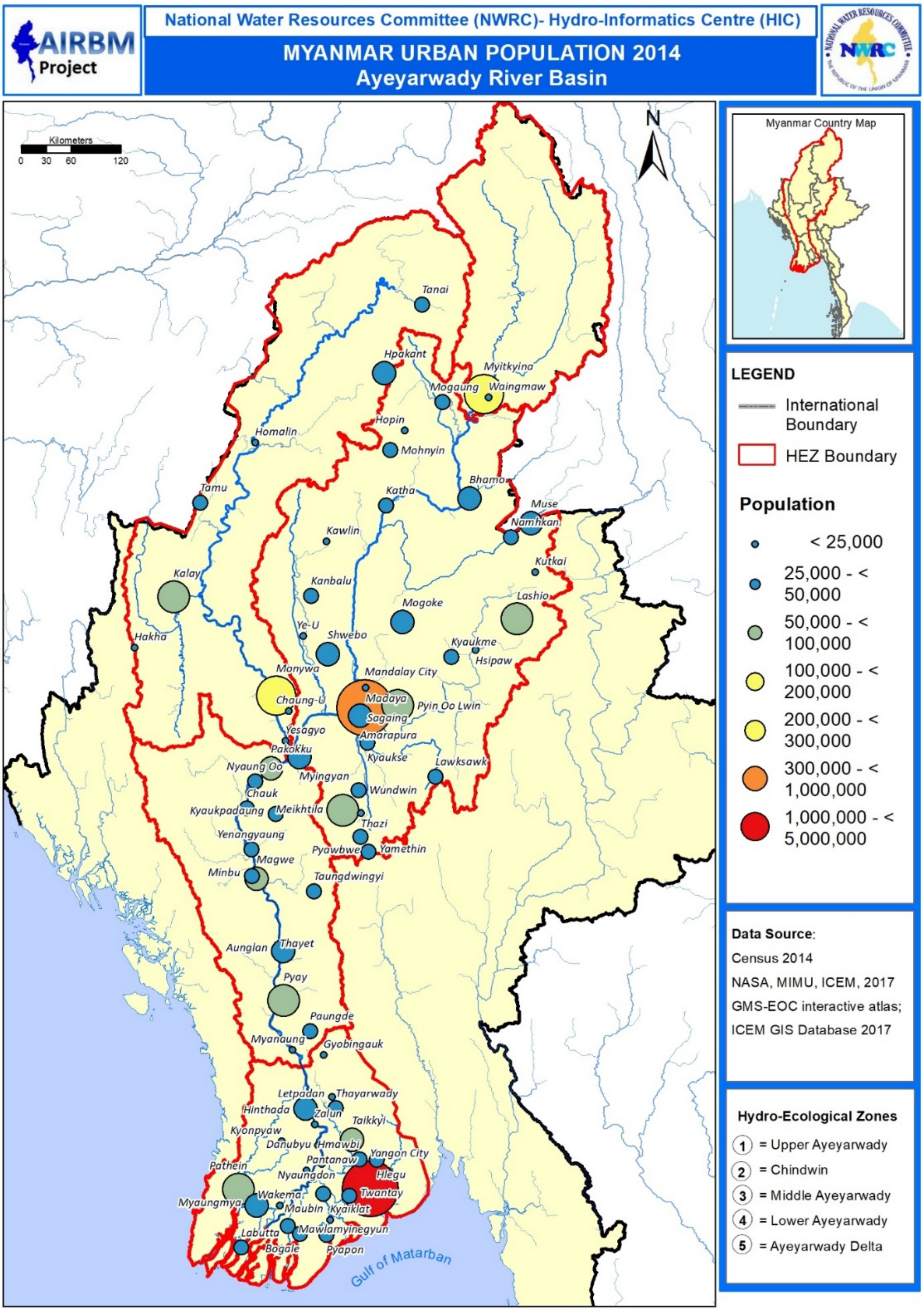


Figure 186 - Urban centres and towns in the Ayeyarwady Basin

10.3.5 *Lower Medium Urban Areas (population 50,000 to <100,000) and Small Population Areas (population <50,000)*

There are 17 Ayeyarwady Basin urban centres in this category. Details are provided in Table 117, and the locations of these cities are shown in Figure 186. Population details of the remaining 141 small population areas are not shown in Figure 187.

Table 117 - Details of Ayeyarwady Basin Lower Medium Urban Centres

Urban centre/state or region	Population (2014)	Hierarchy classification
Hinthada/Ayeyarwady Region	83,762	Tertiary
Myaungmya/Ayeyarwady Region	58,698	
Pyapon/Ayeyarwady Region	52,486	
Bhamo/Kachin State	58,696	
Hpakant/Kachin State	65,857	
Mohnyin/Kachin State	56,642	
Aunglan/Magway Region	52,487	
Magway/Magway Region	94,038	Tertiary
Pakokku/Magway Region	90,842	
Amarapura/Mandalay Region	80,824	Secondary
Mogoke/Mandalay Region	77,609	
Myingyan/Mandalay Region	87,708	
Nyaung-U/Mandalay Region	54,343	
Sagaing/Sagaing Region	81,432	
Shwebo/Sagaing Region	79,739	Tertiary
Tamu/Sagaing Region	59,938	Special purpose
Muse/Shan State	94, 128	Special purpose

10.3.6 *Development Trends*

a) Economic Development Corridors

The government has prepared ambitious economic development plans based around four economic corridors that will impact almost all Ayeyarwady Basin urban centres. These economic corridors development plans include:

- East-West Economic Corridor
- North-South Economic Corridor
- Northeast-Southwest Economic Corridor
- Southeast Northwest Economic Corridor

The summary maps of each of these corridor development plans are provided in Figure 187. Ayeyarwady Basin urban centres that will be impacted by the development proposals are outlined in Table 118. It should be noted that the development of higher value-added manufacturing industry is central to these development plans.

Table 118 - Development proposed for selected Economic Corridors

Economic corridor plan/Ayeyarwady Basin urban centre	Outline of development proposals
East-West Economic Corridor	
Meiktila/Mandalay Region	Growth in hub/key industries - garments and textiles, agricultural crops, transport junction for three regions and Shan State
Nyaung U/Mandalay Region	Growth in hub/key industries - cultural heritage, tourism, handicrafts
Pakokku/Magway Region	Growth hub/key industries - largest market on west bank of Ayeyarwady, industry
Hakha/Chin State	Growth in hub/key industries - border trade route, traditional products

Economic corridor plan/Ayeyarwady Basin urban centre	Outline of development proposals
North-South Economic Corridor	
Myitkyina/Shan State	Growth in hub/key industries - border trade route, transport centre
Mandalay/Mandalay Region	Growth in hub/key industries - hub of border trade routes, international airport, tourism, main market for northern Myanmar
Meiktila/Mandalay Region	Same as above
Northeast-Southwest Economic Corridor	
Muse/Shan State	Growth in hub/key industries - large border trade zone
Lashio/Shan State	Growth in hub/key industries - agricultural products, wholesale markets
Kyaukme/Shan State	Growth in hub/key industries - agricultural products, tea, industry
Pyinoolwin/Mandalay Region	Growth in hub/key industries - tourism, IT industry, service industry
Mandalay/Mandalay Region	Same as above
Meiktila/Mandalay Region	Same as above
Magway/Magway Region	Growth in hub/key industries - agricultural crops, wholesale market, industry
Southeast-Northwest Economic Corridor	
Meiktila/Mandalay Region	Same as above
Mandalay/Mandalay Region	Same as above
Monywa/Sagaing Region	Growth in hub/key industries - agricultural products, wholesale market, mining, India border trade route, industry, tourism
Kale/Sagaing Region	Growth in hub/key industries - agricultural products, industry, market of China and West Sagaing
Tamu/Sagaing Region	Growth in hub/key industries - industry, border trade route

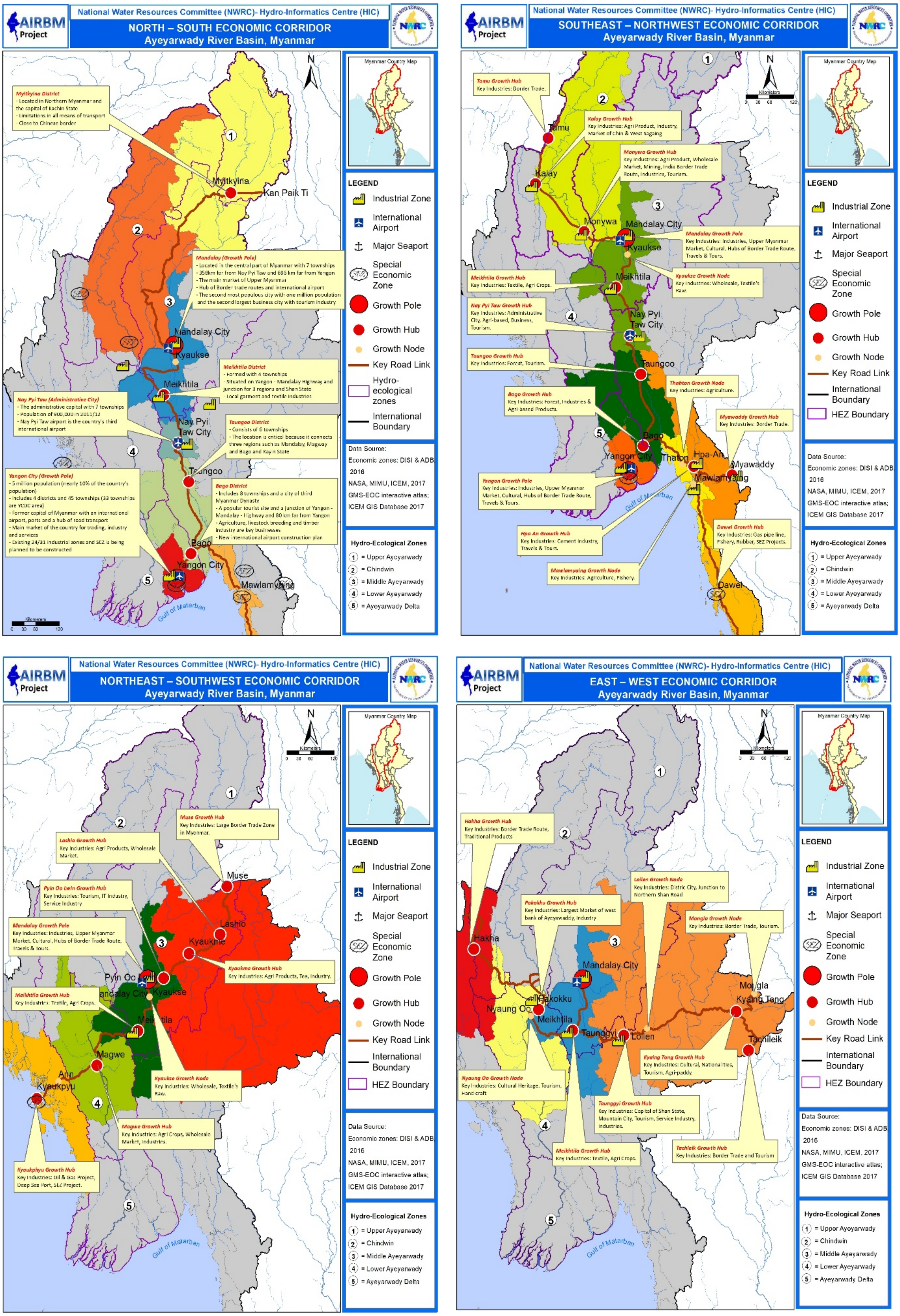
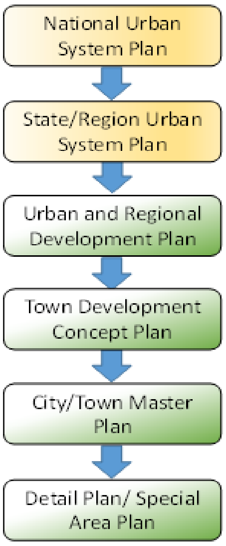


Figure 187 - Myanmar's Economic Corridor development plans

b) DHUD Urban Development Planning



In support of Myanmar's increasing (Figure 188). The colour differentiation shows that the National Urban System Plan and the State/Region Urban System Plans are prepared at the national level, while all of the other plans are prepared at the state, regional, or township level, as appropriate.

All plans are prepared by DHUD staff working with the other government ministries, and the relevant national, state/regional, and township stakeholders.

Since 2014, DHUD has prepared a number of development plans applicable to the Ayeyarwady Basin. State/region and township development plans linked to the following Ayeyarwady Basin urban centres had been prepared and completed at the time of this study: Yangon, Mandalay, Sagaing, Shwebo, Myitkyina, Aunglan, Bagan and Nyaung U, Bago, Bogalay, Chauk, Labutta, Pathein, Magway, Myingyan, Pakokku, Pyay, and Thayet.

Figure 188 - Hierarchy of Urban Development Planning

(DHUD)

10.4 Sector Environmental Issues for River Basin Planning

10.4.1 Water Allocation and Management

Water of a desired quality is often scarce in many parts of the Ayeyarwady Basin, and has to be allocated to different uses such as human consumption, sanitation, the production of food, industry, transport, and energy. Allocation has to be done in a manner that achieves economic efficiency, social equity, and environmental sustainability. Water allocation therefore allows for trade-offs between the priorities of stakeholders, profitability and economic returns, reliability of water supply, equity, and sustenance of ecosystems. Even though water for sanitation is universally classified as a basic need, it is often forgotten in water allocation plans. Therefore, it is important that sanitation planners also participate in allocation planning.

A fundamental consideration for water allocation is that any form of abstraction, transfer, storage, or other influences on the natural stream impacts the entire downstream river system. The water authority (river basin authority) must carry out a system analysis to understand the entire river basin including the associated groundwater and how it affects the livelihoods and economic activities in the basin and vice versa. It is important to allocate water based on its availability and the demands inferred from the ongoing and planned socioeconomic developments (such as population growth, and increases in households with improved sanitation). Water allocation projections provide an important planning tool for adapting to changes in the availability of water. An assessment of environmental water requirements is required so as to reserve a minimum flow to sustain ecosystem services (including water purification, and the actual continued flow of clean water).

For an allocation system to work, all water users (or at least the major users) should be identified, and registered along with their agreed share of water allocated for abstraction or storage (and the conditions that come with the allocation). This is the establishment of a permitting system for the purposes of implementing and monitoring the allocation system. The following are the characteristics associated with an effective permitting system:

- It is time-bound with legal certainty;
- Extreme conditions where special rules apply are described (such as droughts);
- Fees are defined for different uses and volume categories; and
- For each permit, the volume of abstraction, the abstraction rate and times, the point (geographical) of abstraction and source, and the water use should be known.

10.4.2 Watershed and Riverfront Protection

A healthy watershed protects water supplies, nurtures forests, plants, and wildlife, keeps soil fertile, and supports self-reliant communities. Large and sudden changes to a watershed, such as clearing trees and brush, quarrying or sand mining, discharging industrial effluents, dumping waste (solid and liquid), or building roads, houses, and dams, can damage the watershed and its water resources. This can affect the land's ability to support healthy communities, and lead to health problems, hunger, and migration. Planning for changes in how water flows through watersheds, and how water and land will be developed and used, can prevent future problems particularly for urban centres.

Some benefits for urban development when protecting a watershed include:

- More, and cleaner, water resources (surface and groundwater);
- Protection of urban infrastructure along rivers;
- More efficient use of riverbank frontage for loading and unloading from river transport;
- Improved urban drainage;
- Improved flood protection for urban centres; and
- Improved crop yields, even during drier times.

10.4.3 Land Use and Effluent Discharge Permitting

Land use within a catchment affects the amount of water infiltrating groundwater, the rate of run-off and erosion, and the amounts of agricultural chemicals, sediment, and nutrients reaching water bodies. Urban centres and industry produce wastes that can pollute surface and sub-surface waters. Rivers carry pollutants from catchments to the sea. In turn, water availability and quality affect land use and land degradation.

Water resources (surface and groundwater) in the Ayeyarwady Basin are inextricably linked to the surface environment, therefore its quality can be affected by point and non-point sources of pollution in urban centres. Groundwater is used widely throughout the Ayeyarwady Basin for urban water supplies and many aquifers are quite vulnerable as there are no thick overlying clay layers to protect the aquifer from infiltration of contaminants. Some major types of pollution threatening aquifers include:

- **Leachate from landfills and uncontrolled dumpsites** - uncontrolled dumpsites located over and adjacent to productive aquifers are particularly vulnerable.
- **Leakage from service station underground storage tanks** - there are estimated to be a large number of underground storage tanks containing fuel throughout the urban centres in the Ayeyarwady Basin.
- **Leachate from septic tanks and pit latrines** - improperly designed and maintained septic tanks and pit latrines can allow untreated sanitary wastewater to enter and contaminate local groundwater resources and pollute surface waters as well.
- **Infiltration of nutrients and pesticides** - the over-application of fertilizers and pesticides on agricultural lands bordering urban centres. These products can percolate through the subsurface and contaminate local groundwater supplies.
- **Industrial and farm effluent discharges (including mining)** - high-strength industrial and livestock effluent, if discharged directly onto open lands, can infiltrate the soil and affect the quality of groundwater supplies.

It is recommended that, with improved development planning, land use can be more effectively controlled. Legislation requiring industry, farms, mining, and urban authorities to obtain a permit if they plan to discharge any effluents into the natural environments around Ayeyarwady Basin urban centres are necessary. Combined with these, significant capacity building of the state/regional level urban authorities staff will also be undertaken.

10.5 Conclusions

10.5.1 Key Findings

In the Ayeyarwady Basin, there are only 42 urban centres with populations over 25,000 (according to 2014 figures). While Myanmar's major urban centres of Yangon and Mandalay are located in the Ayeyarwady Basin, there are also 116 urban centres with populations of fewer than 25,000 people. The majority are small and still quite rural.

A lack of significant investment in urban services across the cities and towns of the Ayeyarwady Basin for many decades has led to a situation where these cities and towns are now well behind regional benchmarks and do not meet international standards. Major stakeholder concerns identified in these cities and towns include:[55]

- Affordable housing
- Access to land and secure land tenure
- Illegal settlers
- Lack of livelihood opportunities
- Lack of financial assistance
- Lack of skills training
- Lack of access to basic services
- Lack of access to water and sanitation services
- Poor drainage
- Problems with solid waste disposal
- Lack of health centres
- Lack of schools
- Lack of open spaces
- Lack of community involvement
- Road access for emergency vehicles

While urban development planning is now more structured and regulated, and development plans are being prepared, huge capacity and skills gaps remain. These need to be addressed and filled to ensure the proper integration of urban development planning at the national, state, regional, and township level, as appropriate.

10.6 Manufacturing Industry

Promoting the growth of higher value-added production through the development of the manufacturing industry is key to Myanmar's economic growth and development strategy. The Ayeyarwady Basin is the heart of Myanmar's manufacturing industry at present, and in future the development of manufacturing will be an important driver for economic growth in the basin. Manufacturing will add value to the basin's productive natural resource and extractive sectors.

At the same time, the growth in the manufacturing sector will pose challenges for river basin planning. The sector will have significant input requirements. Water demand will increase, as will energy demand - which in turn will drive development of the energy sector in the basin, along with everything necessitated by such growth. Sector demand for other natural resources may also place those resources that are at present not managed in a sustainable fashion, under greater pressure. The sector will also require land resources, which may result in the loss of land available to agriculture and residential use. Manufacturing will also require the development of ancillary transportation infrastructure, to enable goods to access international markets.

The sector will also produce significant amounts of waste products and harmful emissions to air, land, and water are likely to be an important concern. Water pollution in particular is likely to be an issue in areas which have large concentrations of manufacturing industry.

This brief section makes use of limited available data on manufacturing activity in the Ayeyarwady Basin to give an overview of the economic role of the sector nationally and in the Ayeyarwady Basin, highlight the composition of the sector and its distribution across the Ayeyarwady Basin, and understand key challenges facing the sector relevant to river basin planning. The first section takes an overview of the manufacturing

[55] Asian Development Bank. 2016. Making Myanmar's Cities More Inclusive - A Way Forward. TA 8595.

sector in Myanmar, the second section looks specifically at manufacturing industry in the Ayeyarwady Basin, and the final section analyses key issues related to the development of the sector in the Ayeyarwady Basin.

10.7 National Overview of Manufacturing industry

The development of the manufacturing industry is a key part of Myanmar's development strategy. Myanmar is following the same path as other industrialising countries in the region by moving from an economy dependant primarily upon the agricultural and natural resource sectors towards an economy where the modern manufacturing and services sector plays a larger role. Myanmar hopes to emulate the development of other countries in the region through the development of an export-led manufacturing industry, funded through FDI. Rapid growth in the manufacturing sector and supporting industries such as transport and telecommunications suggests that such a development pathway is feasible if supported by continued reform (World Bank, 2016). Figure 187 shows the growth of the industrial sector and manufacturing sub-sector between 2000 and 2016. The industrial sector has grown rapidly over this period, on average at approximately 18% more than double the rate of GDP growth. It has increased its share of GDP from approximately 10% in 2000, to 30% in 2016.

The manufacturing sector has accounted for approximately three-quarters of industrial GDP throughout this period, with an average value-added growth rate of approximately 19% between 2000 and 2015. Although in recent years, the growth rate in manufacturing seems to have stalled relative to industrial growth overall. The growth rate in manufacturing from 2010 - 2015 was on average 14% compared to 15% for industry overall. The reasons for this are not clear, although this change corresponds to the process of political and economic reform which started in 2011, and targeted the manufacturing industry in particular (Abe, 2014).

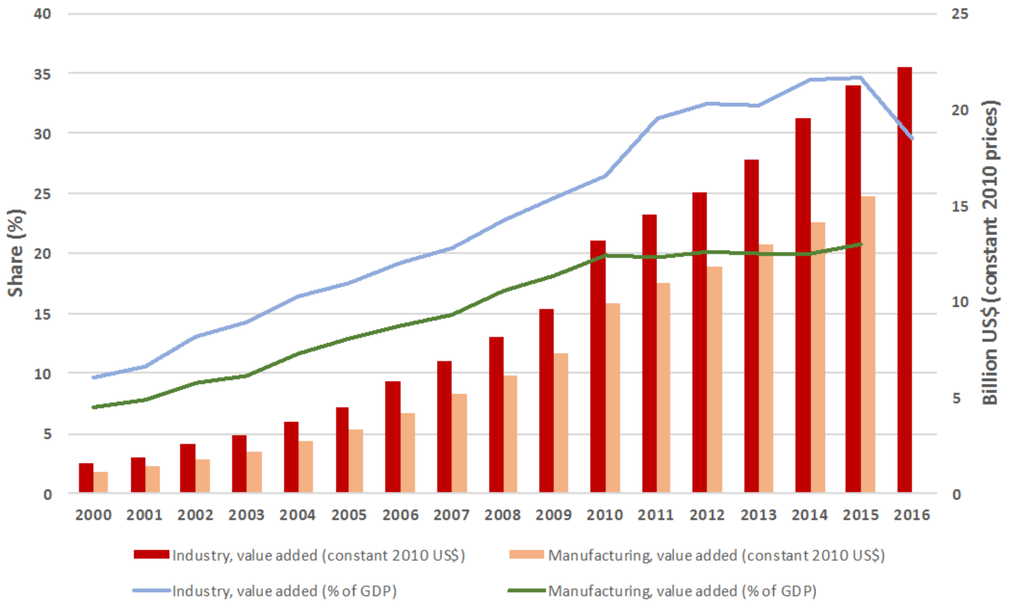


Figure 189 - Industrial and manufacturing sub-sector value added and share of GDP 2000 – 2016

(World Development Indicators Database)

Despite this recent growth, the manufacturing sector remains underdeveloped. Myanmar still imports significantly more manufactured goods than it exports. Though this is not uncommon for rapidly industrializing countries which are upgrading and expanding their stock of capital equipment, Myanmar still remains overwhelmingly dependent upon imports for the supply of even basic manufactured goods, despite its size and abundant natural resources.

There is no consolidated record of manufacturing enterprises in Myanmar. Recent CSO figures from 2014 - 2015 suggest that there were approximately 50,300 officially registered manufacturing establishments. This is roughly in accord with Organization for Economic Cooperation and Development (OECD) estimates suggesting a total of 60,000 registered and unregistered private sector manufacturing firms nationally in 2013 along with a significant number of very small or micro enterprises (OECD, 2014). The vast majority of these firms have fewer than 10 workers (86%), with only approximately 1.5% having more than 100 workers (CSO, 2016). Figure 2 gives the distribution of firms by state/region. State/regions with areas within the Ayeyarwady Basin account for approximately three quarters of all firms. Counting only states/regions fully within the Ayeyarwady Basin, this would be approximately 59% of firms. It should be noted that this under-represents the importance of Yangon and Mandalay, which are likely to have a much higher share of large firms.

Figure 190 (right) also illustrates the broad composition of manufacturing activity by major sub-sector. This largely confirms other observations that the manufacturing sector is dominated by firms in food and beverage manufacture (54%), followed by the manufacture of rubber, plastics and non-metallic minerals (14%), textiles (8%), and basic metals (6%; CSO, 2016).

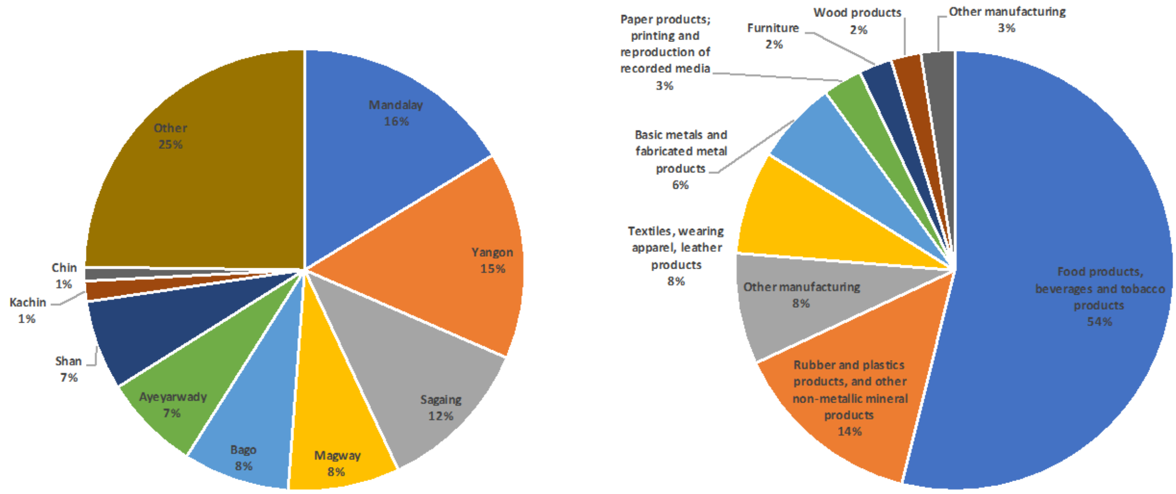


Figure 190 - Share of industrial and manufacturing enterprises by state/region in the Ayeyarwady Basin and nationwide (a) and by manufacturing sub-sector (b) 2014 - 2015

(CSO, 2016)

SOEs remain important in the manufacturing sector. SOE numbers are declining as the reform and privatisation process continues, but in 2013 there were still 639 SOEs represented across a broad range of sub-sectors. While concentrated in traditional SOE territory of heavy industry (such as construction materials, petrochemicals, heavy metal products, and dockyards) SOEs also have an important presence in light manufacturing such as the garment and food and beverage sectors.

Employment in the manufacturing sector stood at approximately 10.6% of the labour force in 2015, or approximately 2.3 million people (Ministry of Labour, Employment, and Social Security and ILO, 2015). A breakdown of the composition of this has not been available. However, figures from 2015 report employment in the burgeoning garments and footwear industry accounts for approximately one-third of manufacturing employment (ILO, 2016). The sector employed approximately 740,000 workers in 2016, most of which are employed in garment production, and 80% of which are women (ILO, 2016).

Growth in manufacturing is being boosted by FDI in the sector. Prior to 2011, most FDI was attracted to natural resource and extractive sectors (mining, agro-forestry, and energy) but since 2012 - 2013 the balance has shifted towards investment in light manufacturing for export (World Bank, 2016; OECD, 2014). In particular, Myanmar's low labour costs are attractive for cost-sensitive, labour-intensive sectors like garment and footwear manufacturing (IMF, 2015). In 2016 - 2017, FDI in manufacturing totalled US$ 1.9 billion more than any other sector, and in the first three months of the 2017 - 2018 fiscal year the sector received US$ 637 million in FDI commitments (Daily Sun, 2017).

Exports are still dominated by gas and natural resources; however, light manufacturing, and in particular the garment and footwear industry, are becoming increasingly important.[56] In 2014 - 2015 exports from these industries exceeded US$ 1 billion. Though exports from this sector did see some stagnation from approximately 2003 - 2008 (Figure 191), the overall trend has been for significant growth, in particular since 2008. The annual growth rate between 2008 and 2014 has been approximately 21%. Economic and political reforms since 2011 seem to have added to the momentum in the sector. The variable share of exports attributable to the sector is mainly explained by the development of large energy projects over the 2000s, which have led to large increases in the energy exports.

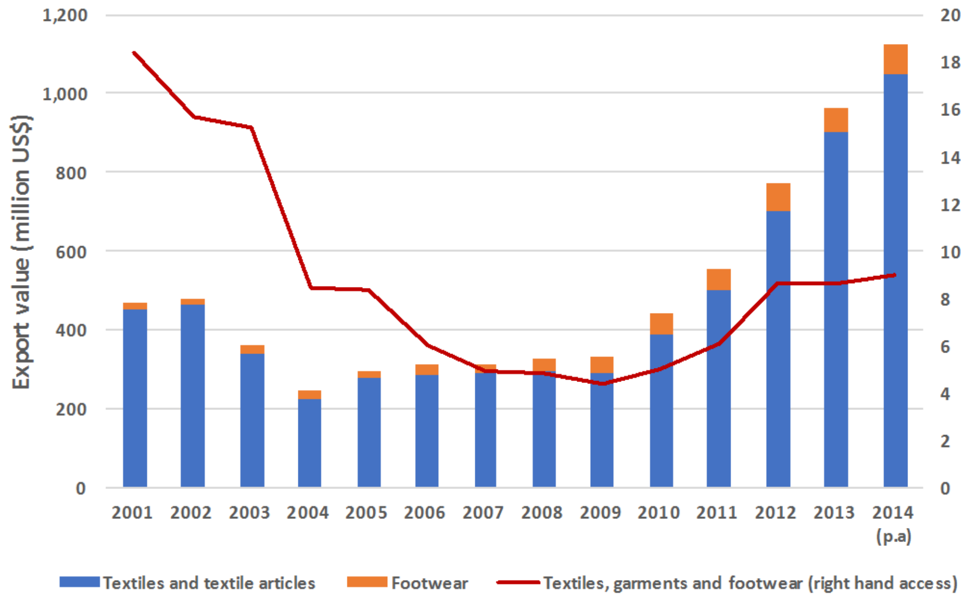


Figure 191 - Textiles, garments, and footwear export value and share of total export value 2001 - 2014

(Customs Department)

An important aspect of government industrial policy has been the development of IZs and SEZs in strategic locations throughout the country. These serve different functions in the country's industrial development strategy. IZs were established in the early 1990s throughout the country to host major SMEs and large manufacturers, whereas micro-sized manufacturers are located outside IZs. At present, 18 IZs have been developed. SEZs by contrast focus on attracting FDI in export manufacturing. The focus is on attracting multinational enterprises which can export and enable access to domestic markets (Abe, 2014). At present the only SEZ is the Thilawa SEZ (Box 5), which is expected to provide an initial platform for export-oriented growth (IMF, 2015).

Box 5 - Thilawa SEZ

(OBG, 2016)

The Thilawa SEZ was the first to be launched in Myanmar. The SEZ is a JV between the government of Myanmar and the Japanese government - the Myanmar Japan Thilawa Development (MJTD). Each government holds a 10% stake in the company, while a consortium of nine local companies hold a 41% stake and the remaining 39% is held by a consortium of private Japanese companies. The zone is located next to two port terminals, the Myanmar International Terminal Thilawa and Myanmar Integrated Port Zone A, which covers a 396 ha area to the south of Yangon. Partial operations were launched in September 2015, and it was 90% complete by August 2016. According to the authorities it had attracted US$ 760 million in foreign investment since operations began. MJTD reported that 73 local and foreign investors had signed on to build factories that will create 15,000 new jobs, with the majority of new investments coming from manufacturers of garments, bottles, construction

[56] This is based on official figures; as pointed out elsewhere this does not account for significant smuggling of precious stones and timber, which means that manufacturing exports actually are likely to account for a smaller share of exports than official figures suggest.

materials, food, steel, fertiliser, auto parts, agricultural machines, medicine, and medical equipment. Of these, 12 have already begun operations, 25 were due to open by the end of 2016, and 30 will be built in 2017.

Operations at Thilawa are expected to provide a major boost to manufacturing output, with MJTD reporting that at current levels of investment, the zone's manufacturing output is set to rise to US$ 241 million annually, while an anticipated US$ 1 billion in new foreign investment will see output grow to US$ 350 million per year. Investment into Thilawa SEZ comprised 12.5% of total FDI inflows in Myanmar during the 2014/2015 fiscal year, with the SEZ's output making up 3% of the country's total exports over the same period. Construction of Thilawa SEZ began at the end of 2016 on a 700-ha plot of land, with the project's size set to reach 2,400 ha once completed.

10.8 Manufacturing Industry in the Ayeyarwady Basin

It is safe to say that the Ayeyarwady Basin probably accounts for most of the manufacturing activity in the country; as Figure 3 illustrates it accounted for roughly 75% of registered manufacturing enterprises in 2014-2015. Given the concentration of large population centres in the Ayeyarwady Basin and the rapid growth of the sector, this is likely to underestimate the Ayeyarwady Basin's share of national economic output. Indeed, recent figures suggest that three quarters of garment and footwear manufacturing employment are located in Yangon (302,100), Mandalay (152,500), and Sagaing (87,100), not to speak of garment manufacture elsewhere in the basin such as in the Ayeyarwady Region.

However, neither spatially disaggregated data on manufacturing firms, their location, and activities nor patterns of growth in the Ayeyarwady Basin have been available. The brief analysis here is based on data that was available regarding manufacturing industry in the IZs and SEZs situated with the Ayeyarwady Basin.

10.8.1 Industrial and special economic zones in the Ayeyarwady Basin

Figure 5 shows the location of the IZs and SEZs within the Ayeyarwady Basin. With the exception of Kachin State and the Upper Ayeyarwady HEZ, all states/regions and HEZs have IZs. The largest and best established are located in and around the two largest urban centres of Yangon and Mandalay, with Yangon in particular seeing a concentration of investment both in IZs and investment commitments in the newly opened Thilawa SEZ (Table 119). Overall, the size of companies within IZs seems relatively small, with an average number of employees of 33 and average investment capital of approximately US$ 70,000. The exceptions to this are Yangon IZs and the relatively new Sagaing IZ, both of which have an average size of approximately 58 employees and investment capital of US$ 129,000 and US$ 124,000, respectively. This reflects the national picture of the manufacturing sector dominated by SMEs.

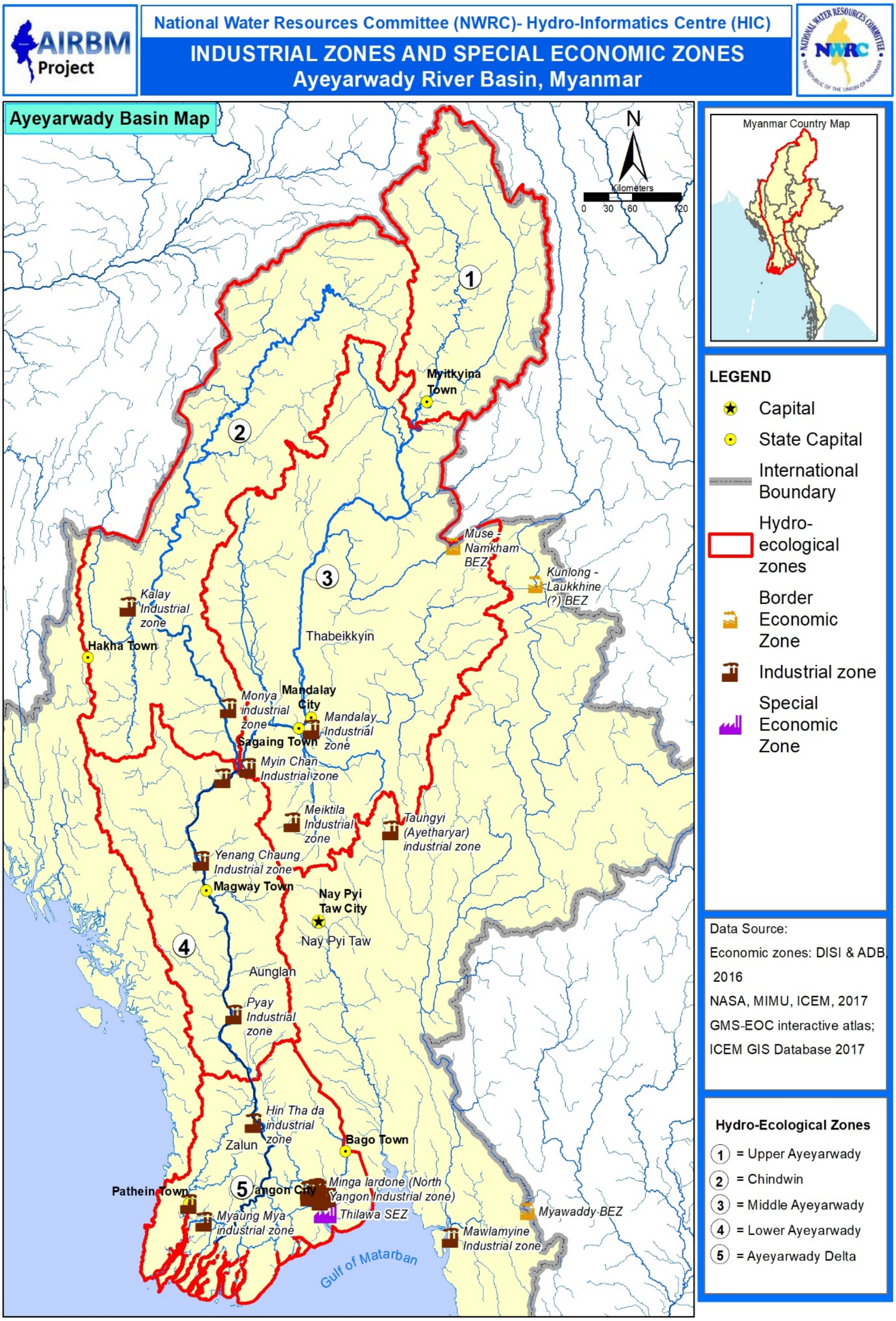


Figure 192 - IZs and SEZs in the Ayeyarwady Basin

Table 119 - IZs and SEZs in the Ayeyarwady Basin 2017

(DISI)

Region/state	IZ/SEZ	Year of opening	Number of companies	Area (ha)	Number of employees	Investment (US$ million)
Yangon	North (19)	1990	2,989	4,489	176,130	386.2
	East (10)	1996		1,464		
	South (2)	1992		175		
	West	N/K		N/K		
	Thilawa SEZ[57]	2016	69	2,342	N/K	488.9
Mandalay	Mandalay	1990	1,257	737	15,944	52.7
	Myingyan	1995	249	66	1,367	0.9
	Meiktila	1997	301	156	2,252	0.8
Sagaing	Monywa	1999	448	85	3,002	3.7
	Shwebo	2004	118	81	744	1.2
	Sagaing	N/K	63	389	3,660	7.8
Magway	Pakokku	1998	238	153	1,097	0.8
Bago	Pyay	1992	190	83	932	1.1
Ayeyarwady	Pathein	1993	50	102	6,101	1.0
	Myaung Mya	1995	10	24	88	0.1
	Hinthada	1995	9	35	69	0.1
Shan	Taung Gyi (Ayethaya)	1995	466	365	2,514	10.6
Total			**6,457**	**10,745**	**213,900**	**955.8**

Figure 193 gives the composition of firms by sub-sector in terms of investment, employment, and number. The figures clearly show the importance of garment, food and beverage, and construction material manufacturing. As noted above, the garment industry is an important source of employment generation in IZs, with a much larger average number of employees than any other sector; over 180 on average compared to an average of 34 for all sectors. At the same time, the sector has a relatively low capital intensity. After the garments sector, as noted elsewhere the food and beverage sector is the next most significant, accounting for the highest number of firms in IZs and employment of approximately 33,000. The sector is characterized by small enterprises, again with generally low capital intensity. Production of construction materials (bricks cement, etc.) represents the next largest sector in terms of employment and investment.

[57] It is unclear from available information the extent to which investment commitments for Thilawa SEZ have been realised, and it is likely that the current data pertains to potential investors and committed investment in the SEZ.

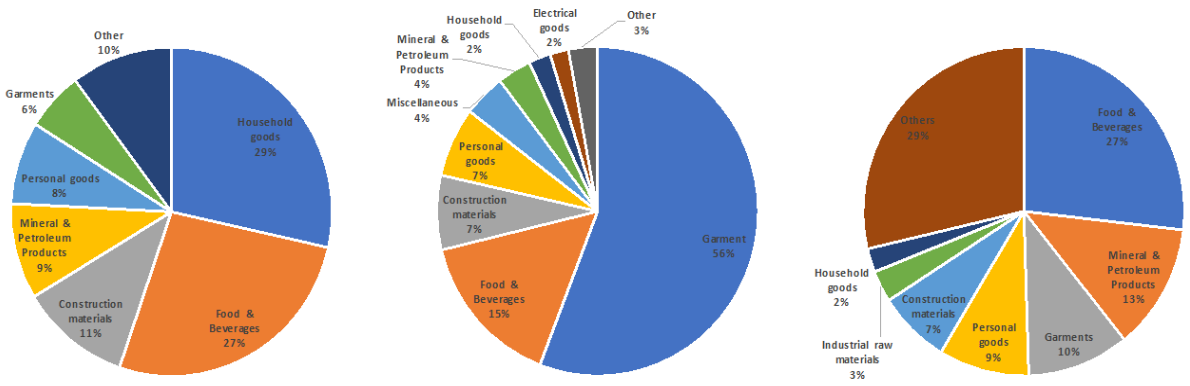


Figure 193 - IZ enterprises in terms of investment (a), employment (b), and number (c) by major sub-sector 2016

(DISI)

Figure 194 shows the breakdown of firms by sector in IZs in terms of investment, and perhaps more importantly, employment by sub-sector in Figure 195. Investment in food and beverage manufacturing appears to be important across all IZs. Garment manufacturing by contrast is much more important in Pathein, Meilktila, and Yangon. Mineral and petroleum product manufacturing is important in locations close to sources of resource extraction, such as Monywa and Mandalay. In considering these investment figures, it is important to bear in mind that Yangon and Mandalay IZs together account for 94% of investment in IZs in the Ayeyarwady Basin.

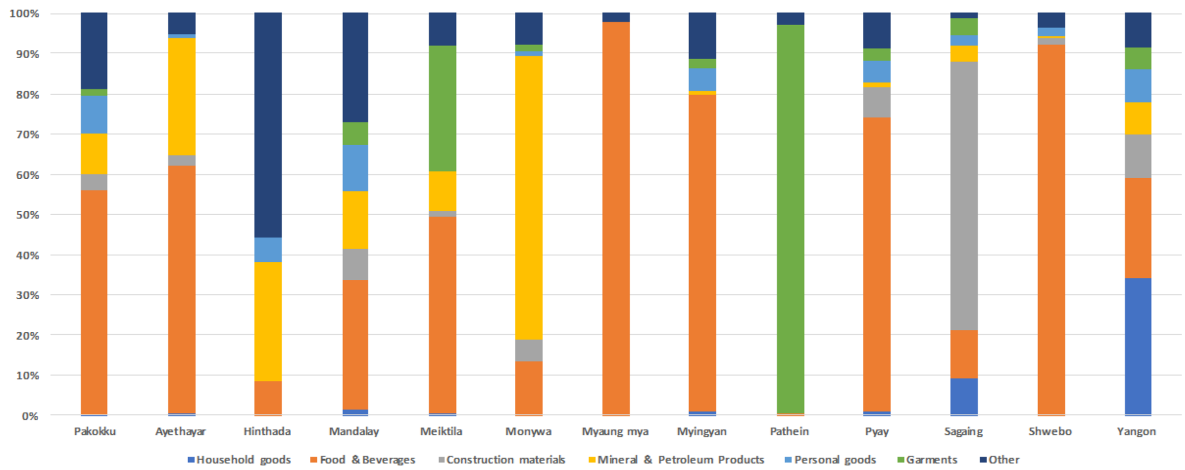


Figure 194 - Share of cumulative investment by sector in Ayeyarwady Basin IZs by sub-sector (a) and by share of IZ investment (b) 2016

(DISI)

Figures on employment show a similar pattern. Employment in garment manufacturing is concentrated in Yangon, Pathein and Meilktila. Employment in the food and beverage sector is important in most of the IZs. Aside from this, the importance of the production of construction materials in Sagaing also stands out. Together Yangon and Mandalay IZs account for approximately 89% of employment in Ayeyarwady Basin IZs.

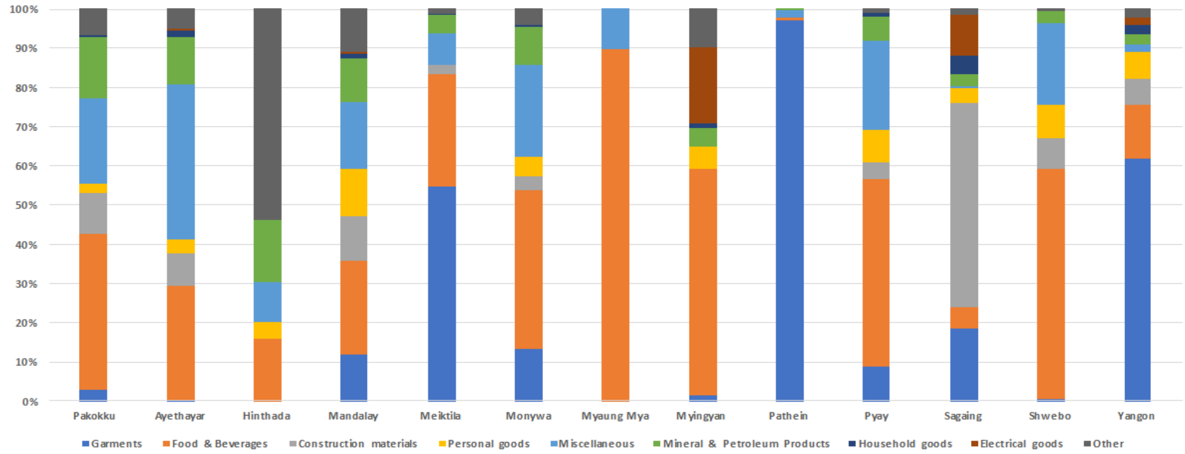


Figure 195 - Share of Ayeyarwady Basin IZ employment by sub-sector 2016

(DISI)

10.8.2 Key issues for manufacturing industry

The development of the manufacturing industry in the Ayeyarwady Basin and Myanmar in general, faced a number of well-known issues relating to the poor business environment in the country as a whole. The 'Doing Business' survey ranked the country a poor 177th (Figure 196). This poor performance is due to a weak legal and institutional environment for the operation of a business as well as more basic issues with obtaining property. Myanmar also performs poorly in terms of infrastructure provision, with the provision of logistics and electricity particularly problematic (see sections on energy and transport).

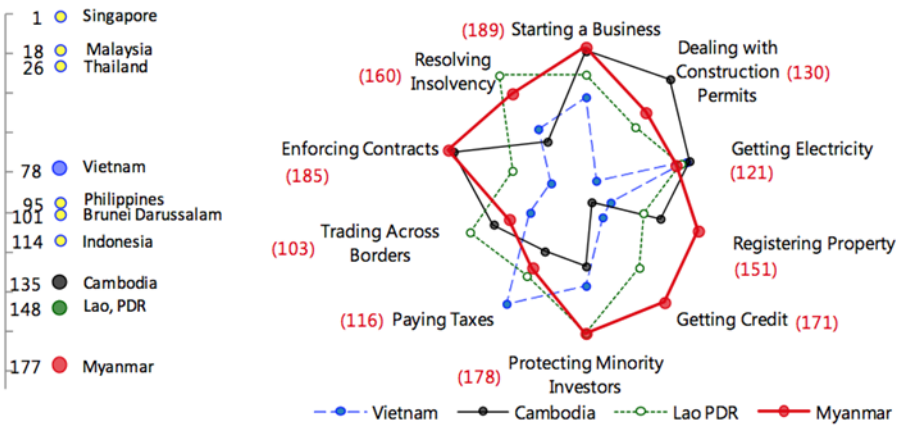


Figure 196 - 'Doing Business' in Myanmar - summary of business environment in comparison to other countries 2015

(IMF, 2015)

The manufacturing sector also faces a range of social and equity issues. These include low wages, labour unrest, poor working conditions, and concerns relating to occupational health and safety (Oxfam, 2015). The development of SEZs and other manufacturing facilities has required the appropriation of land, which has led to issues related to involuntary resettlement and the loss of farm land, which have, in some cases, been problematic.

From a river basin planning perspective there are a number of environmental and water related issues that need to be considered. These include:

- **Location of manufacturing plans in flood zones** - most IZs and SEZs are in floodplain areas. The extent to which flood risk has been considered in the siting and design of these facilities is unclear. Recent floods in Thailand illustrate the potential hazards associated with the siting of valuable and sensitive production facilities in flood prone areas. It is unclear if this is the case with manufacturing establishments in the Ayeyarwady Basin.
- **Pollution emissions** - the manufacturing industry is likely to be a key potential source of pollution in the future. Rapid development of water intensive sectors, such as textiles and food and beverage manufacturing, is likely to result in rapid increases in wastewater emissions. It is neither clear if water treatment facilities are installed at IZs or SEZs in the Ayeyarwady Basin, nor is it clear what portion of manufacturing plants outside designated zones have water treatment plants. The experience in the region has not been good and water quality issues have become critical in areas seeing rapid development of the manufacturing sector (such as the Pearl River in the PRC and the Dong Nai River in Vietnam). Pollution and water quality issues may be particularly acute in the dry season and in areas downstream of large industrial facilities or agglomerations around large urban areas (such as Yangon and Mandalay).
- **Pollution from cottage industries** - elsewhere in the region (PRC, Thailand, and Vietnam) the phenomenon of village clusters of micro and small manufacturing industries have caused important localized pollution issues. Such villages tend to specialize in manufacturing particular products. This provides valuable spill-over benefits for producers but also concentrates the impacts of many small manufacturing establishments in a single geographical area. This can cause pollution problems, which are often compounded by the use of inefficient and antiquated technologies or processes, a lack of knowledge relating to pollution impacts among producers and an inability to effectively mitigate pollution risks.
- **Indirect impacts** - the development of the manufacturing industry will require the development of adequate supporting transportation infrastructure, which may have important environmental outcomes. Development of the manufacturing industry and the employment it generates may result in population movement and a concentration of demand for services and amenities in and around the peri-urban manufacturing locations.

10.9 Conclusions

After decades of stagnation, the manufacturing sector in Myanmar is starting to take off. The country hopes to follow the export-led development model followed by other countries in the region. This development is likely to be centred in the Ayeyarwady Basin, in particular in Yangon and Mandalay. Recent growth has been concentrated in the garment and footwear sectors. However, this is likely to expand to other sectors as the economy grows. Meeting domestic demand for basic goods is likely to be key, as is adding value to the basin's abundant natural resource output.

Development of the sector will pose challenges for basin management in terms of flood risk, water use, pollution, the development of ancillary infrastructure, and changing population dynamics. However, a proper evaluation of the sector in the Ayeyarwady Basin is stymied by a lack of information on the number, location, size, and type of manufacturing activity in the basin. Without this, it is not possible to identify likely impacts of sector development or their significance for sustainable development in the Ayeyarwady Basin.

Therefore, the first step in addressing the sector needs to be the development of a comprehensive database of manufacturing industry in the basin. The database would include a number of elements including location of the factory site, the activities ongoing at that site, size of investment, revenue and output figures, employment, water abstraction/use figures, energy use figures, and information on the quantity and type of pollution emissions (to water, air, and land), as well as pollution control investment, if any.

11 EQUITY AND DISTRIBUTIONAL ISSUES

11.1 Introduction

In general, Myanmar's rapid economic growth (Chapter 2) has led to significant declines in poverty and improvements in livelihoods (Chapter 4). Based upon the latest estimates, between 2004/2005 and 2009/2010 the poverty rate has declined from 44.5% to approximately 37.5%, and by 2015 it had declined further to an estimated 26.1% (MPF and World Bank, 2017). At the same time, all indications are that levels of inequality have risen (Table 120). Inequality remains relatively low in comparison to other countries in Southeast Asia and a number of OECD countries.[58] This has been driven by the urban-centred growth and relative stagnation in the agricultural sector (Introduction). At the same time, there are indications of growing inequalities in urban areas (World Bank, 2017).

Table 120 - Measures of inequality 2015

(World Bank, 2017)

	National	Urban	Rural
Gini	31.7	36.6	28
Theil-0	17.1	22.5	13.1
Theil-1	20.6	29.1	13.7
Share bottom 20%	8.4	7.6	9.1
90/10	3.7	4.2	3.4
90/50	2	2.1	1.9
50/10	1.9	2	1.9

Increases in inequality are not surprising as economic growth and liberalization opens up opportunities for individuals with the requisite skills or capital to benefit from the economic expansion; however, these are opportunities which will not be open to everybody (World Bank, 2017). Some degree of inequality in a developing country context may be desirable in incentivizing more productive activities and better enabling some individuals to accumulate human and financial capital to invest in productive activities. However, economic research has shown that generally speaking, higher inequality is bad for growth and the sustainability of growth for a number of economic, social, and political reasons (IMF, 2015).

Inequality can affect economic growth and more general societal wellbeing in a number of ways. Firstly, equality of opportunity is a form of societal fairness, valued in many societies. Persistent and rising inequality is often indicative of a lack of social mobility and reflects persistent patterns of disadvantage affecting certain segments of society. The widening of inequality can act to concentrate material wealth and social and political power in the hands of certain groups, which can affect political stability, which in turn makes realizing developmental goals more difficult (IMF, 2015; UNDP, 2013). As a recent report for the UNDP puts it:

'…inequality has been driving conflict and destabilizing society. When incomes and opportunities rise for only a few, when inequalities persist over time and space and across generations, then those at the margins, who remain so consistently excluded from the gains of development, will at some point contest the "progress" that has bypassed them. Growing deprivations in the midst of plenty and extreme differences between households are almost certain to unravel the fabric that keeps society together' (UNDP, 2013).

Secondly, inequality in developing countries tends to reduce the poverty-reduction impact of economic growth. Groups suffering from inequality are unable to invest in human capital development, meaning people are unable to fulfil their productive potential thus affecting economic growth. Groups disadvantaged

[58] For example, Mexico, Chile, Turkey, Russia, the USA, and the UK all have higher levels of inequality as measured by the Gini co-efficient.

by unequal access to material resources are often deprived of access to education, health, and nutrition needed for achieving a reasonable level of well-being.

The national picture of inequality in Myanmar (and by implication the Ayeyarwady Basin), may imply that inequality it not at a problematic level. However, with over one-third of the population living below the poverty line; significant disparities in access to key resources and services between different geographical locations (see Chapter 4); persistent gender inequality; and perceptions of inequitable resource exploitation feeding into continuing low-level ethnic civil conflict in the basin; inequality and distributional issues in the country and basin remain an important concern.

This section seeks to dig beneath these aggregate figures and explore a number of cross-cutting equity and distributional issues, which are important in understanding the Ayeyarwady Basin context but that are not covered elsewhere in the socioeconomic report. These are land tenure, gender, and peace and conflict. The first section of this chapter looks at issues related to access to land, which is a key distributional issue in the basin and a continuing source of local level disputes and in some cases conflict. Section 3 looks at issues related to gendered inequalities nationally and in the Ayeyarwady Basin. The final section looks briefly at conflict in the basin, highlighting its impact on natural resource development.

11.2 Access to Land and Land Tenure

11.2.1 Introduction

Land is the single most important asset for most households in Myanmar. Moreover, as approximately 70% of the population are involved in agriculture and related activities, land also represents their main means of subsistence. The rapid economic changes Myanmar is currently undergoing are resulting in dramatic consequences to land access and tenure. With increasing investment, land in certain locations is increasing in value. Under previous governments, the state was the main owner of all land, either directly or through proxy companies. Land tenure reforms are currently underway, giving small-holders greater legal rights over their land. At the same time, increasing economic activity in certain sectors is putting existing land tenure arrangements under pressure. This is particularly common in upland areas of the basin, which have seen extensive development of agro-forestry plantations (Chapter 6), mining (Chapter 7), oil and gas infrastructure (Chapter 8) and HP (Chapter 8). Land disputes are increasingly common throughout the country and Ayeyarwady Basin.

This section takes a brief look at issues related to land disputes and land tenure in the Ayeyarwady Basin. We develop this issue as access to land, land tenure, and management rights will be a central issue in managing the river basin in years to come. Land disputes are also often the cause of long-standing grievances and conflicts that continue to plague the Ayeyarwady Basin.

11.2.2 Key land-associated issues in Myanmar and the Ayeyarwady Basin

a) Weak rural land tenure

Much of the land tenure in Myanmar and the Ayeyarwady Basin is held on an informal or semi-formal basis. In the case of rural land, many land holdings do not have their tenure formally registered. A considerable amount of land in the basin and nationwide is also used communally, under customary land tenure arrangements. This is especially the case in upland, ethnic minority areas, as a longstanding and widespread practice. In both cases this often leads to weak tenure rights and very limited protection for landholders (MSRB, 2015). These upland areas have been the location of the development of land concessions for agribusiness, mining, HP, and other resource development, and where land loss has been most common. Appropriation of large areas of land has been enabled by the customary tenure rights land users enjoyed not currently being recognised in law (Scurrah et al., 2015).

Recent figures suggest that land concessions granted largely for agri-business in upland areas, totalled nationally approximately 1.4 million ha in 2016, up from approximately 590,000 ha in 2007, and approximately 162,000 ha in 2000 (San Thein et al., 2017). In the Ayeyarwady Basin, large tracts of land have been granted for agri-business concession in Kachin and Northern Shan states. In this context, it should be noted that some government policies such as the Agricultural Master Plan (2000/2001 - 2030/2031) favor the development of large agribusiness to produce industrial scale production of crops for export. The plan proposes the conversion of 10 million acres of under-utilized land for this purpose - however, much of this land is already occupied by farmers under customary tenure arrangements (MSRB, 2015).

b) Increasing landlessness

At the same time, rural households are at risk of losing their land due to poverty and debt. Over several decades this has led to increasing levels of landlessness among the population. Landlessness and its corollary, the concentration of land ownership, have long been recognised in Myanmar as key economic and social issues. Estimates from 2005 suggest rural landlessness was approximately 26% across the country, with the highest levels in the Ayeyarwady Basin in Yangon Region (39%), Bago Region (41%), and Ayeyarwady Region (33%). A more recent survey of 4,000 households conducted in 2012 found that 50% of households did not own land, suggesting a significant increase from 2005. Again, important areas for rice production showed the highest levels of landlessness, with the proportion of landless households in the Delta/Coastal Zone at 72%, in the Dry Zone at approximately 43% and in upland areas much lower at 26% (LIFT, 2012). Other studies have also suggested that landlessness is nationally approximately 50% (Oxfam, 2014). The commercialisation of agriculture is only likely to increase the levels of landlessness as smaller holdings gradually become less commercially viable and unable to compete with larger scale, high-input farming systems.

At the same time, the agricultural census noted the expansion both of average land holding size and of parcel size nationally, suggesting that increasing landlessness is being accompanied by an increasing concentration of productive assets in other households, and an increasingly unequal distribution of land (See Chapter 2 on agriculture).

c) Displacement due to conflict

Displacement due to conflict is an issue in some northern parts of the Ayeyarwady Basin in Kachin State and Shan State. Land tenure arrangements, predating displacement were in many cases already customary and informal. Displacement has attenuated these rights even further. In some cases, land has been taken over by other users and in other cases, the land remains unoccupied for years. Either way, this also presents an important land issue in some areas of the Ayeyarwady Basin (MCRB, 2015).

d) Urban areas

Rent and land prices have been climbing dramatically in the large urban areas of the Ayeyarwady Basin. The influx of foreign investment and international companies and organisations is driving much of this growth. These changes have also been a factor in driving recent land disputes. At the same time, a more liberal political environment has enabled people to protest former land appropriations, real estate developments, and the development of IZs and SEZs, typically on farmland in peri-urban areas. The appropriation of land for these purposes has also been a source of conflict. The Ayeyarwady Basin's larger urban areas also contain large numbers of people living in informal settlements or slums. These households only have very weak informal tenure (MCRB, 2015).

Issues related to the appropriation of land in and around the Ayeyarwady Basin's large urban areas are likely to become more acute as rapid urban development continues. There are already conflicts related to historical involuntary resettlement and expropriation of land, which took place in the 1990s in Yangon (MCRB, 2015). There have also been land related issues connected to the Thilawa SEZ in Yangon (Donateo, 2017). In Mandalay the development of Myotha Industrial Park has created land issues with land losses affecting 1,000 households from 14 villages (FIDH, 2017).

11.2.3 Land policy and administration

While the 2008 Constitution provided for private property rights, it also maintains that the state is the 'ultimate owner of all lands and all natural resources' and shall 'supervise extraction and utilization of state-owned natural resources by economic forces'. The current land regime is characterized by a patchwork of new and old laws that leads to overlap, contradiction, and confusion. Over 30 legislative instruments govern land management, some of them dating from the 19th century. At least 20 government agencies are involved in land issues, with a complex system of varying structures at both the national and sub-national levels. In ethnic minority areas, local governments and military commanders have significant influence over land policy; for instance, the Karen National Union has its own Land Use Policy and registration procedures, although this is not recognized by the national government.

As noted above, insecurity of tenure is a major problem. Moreover, the land registration system is considered inefficient, with complex requirements and lack of tangible benefits for registering land. The cadastral system is incomplete and outdated. This can be a further cause of dispute, as land classifications and mapping used by different government ministries can overlap and fail to reflect current land use. For example, a plot may be classified on maps as RF land, when in fact the land may have been used as farmland for many years already, without the classification having been changed or updated (MCRB, 2015).

A recent investment policy review conducted by the Organisation for Economic Co-operation and Development (OECD) commented that, 'Land tenure remains insecure for most smallholder farmers for a wide range of reasons: i) a complex and long registration process resulting in low land registration rates; ii) rigid land classifications that do not reflect the reality of existing land use; iii) lack of recognition of customary land use rights; iv) weak protection of registered land use rights; v) inefficient land administration; and vi) active promotion of large-scale land allocations without adequate safeguards' (OECD, 2014).

11.2.4 Conclusion

Access to land, land tenure, and broader land administration are important issues in Myanmar and the Ayeyarwady Basin in particular. The current land administration leaves much to be desired. Land policy reforms are being developed; however, issues relating to informal tenure, overlapping land use/tenure rights, historical land disputes, and outdated and incomplete cadastral records, not to mention the presence of semi-autonomous jurisdictions within the Ayeyarwady Basin, which grant alternative land tenure rights, remain.

The weak tenure and land administration context is likely to be an important factor restricting the more rapid development of small-holder agriculture. Stronger tenure could act to unlock small-holder investment, by enabling the collateralisation and mortgaging of land, and providing adequate security to enable long-term investments in the improvement of agricultural assets.

11.3 Gender

11.3.1 Overview and data limitations

Gender disparities remain an important source of inequality in Myanmar. While it ranks 85th out of 187 countries in the 2014 Gender Equality Index,[59] there remain important gender-based inequalities in legislation, access to economic opportunities, and political representation.

The United Nations Population Fund (UNFPA) notes that action on gender equality is hindered by a lack of research and statistics on gender outcomes. This has also presented a difficultly in developing the Ayeyarwady Basin analysis (UNFPA, 2017). Given the absence of available evidence and especially geographically disaggregated evidence related to gendered outcomes that would allow the identification of gender characteristics or trends in the Ayeyarwady Basin, we are restricted to a general discussion of gender trends in the country as a whole, picking up the limited data on gender differentials in the Ayeyarwady Basin where this is available. The focus in this section is on gender issues relevant to river basin planning, and specifically on basic demographic and socioeconomic gender disparities. Other issues, such as the representation of women in political processes and governance institutions, issues related to women's health and violence against women, and issues such as human trafficking, while clearly of urgent importance, are deemed beyond the scope of this analysis and are not considered in this section.

[59] The GII is a measure of gender-based inequality based on three dimensions: reproductive health, empowerment and economic activity (UNFPA, 2017).

11.3.2 Demographic gender disparities

As pointed out in Chapter 1 on Demographics, the 2014 Census shows a general imbalance in the number of men and women, with 93 males for every 100 females, which contrasts with the global ratio of 101 males to 100 females. Data from 1973 and 1983 suggest this is part of an established trend in a declining male percentage of the population. This varies significantly between regions of the country and the Ayeyarwady Basin, with areas such as Kachin, which attracts a high number of male migrants to its jade mining areas. Urban areas and areas that are the source of male migration have higher proportions of females to males. The overall results suggest higher female survival rates, but are also possibly the result of greater male migration rates. This finding is supported by the observation that the male to female ratio starts falling past the 0 - 15 age cohort, when males enter the workforce and start looking for work, which may take them abroad (UNFPA, 2017).

Marriage and fertility patterns also have an impact on gender equality. At the national level, the proportion of women that are married (57.8%) is lower than that of men (61.4%). This may be explained by the shorter life expectancy of men and consequently higher prevalence of widowhood among women (10.4%) than men (3.1%; UNFPA, 2017). This varies across the country. In the Ayeyarwady Basin, the proportion is approximately equal, but in states such as Kachin with a lot of male in-migration, there are lower levels of married men relative to women. The average age of marriage in 2014 for women was 23.59 years old and 25.87 for men—a gap of 2.28 years. This gap narrows in regions such as Yangon, Sagaing, and Magway and is significantly higher in Kachin and Shan (UNFPA, 2017). Although the average age of marriage exceeds the age of secondary school completion, there is a significant difference in the number of adolescent marriage among males and females. In 2014 13,108 girls and 3,860 boys aged 15 were married. Adolescent marriage is deemed harmful to girls and is linked with health risks for mothers and children, increased fertility, and decreased economic and educational opportunities (Parsons et al., 2015). Fertility rates in Myanmar are relatively low in comparison to international standards, but there is significant variation across the country with the highest adolescent fertility rates recorded in Shan (59 births per 1,000 women) and Chin (50 births per 1,000 women) states, and lowest in predominantly urban regions of Yangon (21 births per 1,000 women) and Mandalay (23 births per 1,000 women).

In line with global trends, female infant mortality rates (IMR) and life expectancies are better than those for men. IMRs are influenced by levels of nutrition, immunization, and health care, as well as general living standards and living conditions in communities. The IMR in Myanmar in 2014 was relatively high in comparison with some other ASEAN countries, at 62 deaths per 1,000 live births. The gender gap in IMRs was 16.3 overall.[60] At a sub-national level the gap was generally lowest where overall IMR was lowest, and highest where IMR was highest. Similar considerations are applicable to CMR.

Life expectancy at birth also tends to be longer for females than males. This is due in part to physiological factors, but the large disparity is thought to be due to sociological and cultural factors (UNFPA, 2017). The gender gap in life expectancy is larger in urban areas than rural areas, but it is important to bear in mind that in some of the areas with the lowest gender life expectancy gap, such as Chin, life expectancy for men and women is lower than in locations such as Yangon, which show a larger life-expectancy gap. Key demographic differences between genders for Ayeyarwady Basin regions and nationwide are summarized in Table 121.

Table 121 - Demographic gender indicators by geographical region 2014

(UNFPA, 2017)

Area	SMAM gender gap[61]	Adolescent fertility rate[62]	CMR - survival advantage[63]	IMR - survival advantage[64]	Female life expectancy advantage[65]
Urban	1.99	22	-	-	11.26

[60] Male IMR was 69.9 and female 53.6 in 2014.
[61] SMAM: Singulate mean age at marriage, gender gap in years (Male SMAM - Female SMAM)
[62] Births per 1,000 women ages 15 – 19
[63] Child mortality rate (deaths per 1,000 population) survival advantage (Male CMR - Female CMR)
[64] Infant mortality rate (deaths per 1,000 live births) survival advantage (Male IMR - Female IMR)
[65] Female life expectancy at birth - Male life expectancy at birth

Area	SMAM gender gap[61]	Adolescent fertility rate[62]	CMR - survival advantage[63]	IMR - survival advantage[64]	Female life expectancy advantage[65]
Rural	2.38	38	-	-	8.07
Kachin	4.24	37	1.7	10.9	9.95
Chin	2.89	50	2.4	16	6.12
Sagaing	1.67	31	2.3	14.3	9.47
Bago	2.32	28	4.1	21.6	9.03
Magway	1.45	27	4.7	25	10.41
Mandalay	1.49	23	2.9	16.4	10.49
Yangon	1.73	21	1.9	13.3	10.27
Shan	3.1	59	1.9	12.3	8.85
Ayeyarwady	2.59	40	4.5	24.2	7.02
National	2.28	33	3	16.3	9.16

11.3.3 Socioeconomic and other gender differences

Women tended to have a lower labour force participation rate than men overall, at 47.1% compared to 81.7% for men, for people aged 15 and over (UNFPA, 2017). There are reports that employment remains segmented by gender and women's employment is concentrated in the informal sector. Women also tend to bear responsibility for unpaid care work and men are typically household heads (ADB, 2016). Women remain concentrated in certain employment sectors. For example, of the 350,000 plus workers in the rapidly growing garment sector, 90% are women (SOMO et al., 2017), which accounts for approximately 30% of the women employed in manufacturing. In this sector, significant pay differentials persist between men and women (ILO, 2016).

Table 122 summarizes data on gender disparity from the IHLCS conducted in 2010. The data illustrates some key areas of gender disparity, in particular in terms of labour force participation, as well as some minor differences in incidence of unemployment, and poverty indicators such as malnutrition and primary school enrollment rates.

Table 122 - Gender disparity by socioeconomic characteristics

(IHLCS, 2009 - 2010)

Characteristics/indicators (2010, unless specified)	Percent of	
	Male	Female
Proportion of population in agriculture, hunting, and forestry	52.3	47.4
Proportion of population as casual labourer	19	16.6
Proportion of population as employer	6.4	4.1
Proportion of agriculture households with access to credit	33.2	32
Proportion of non-agriculture households with access to credit	11	11.4
Labor force participation rate: previous 6 months (among persons 15 years and older) (2014 census data)	81.7	47.1
Underemployment rate: previous 7 days (among persons 15 years and older)	1.5	1.9
Proportion of population with self-reported morbidity incidence	34.9	41
Proportion of malnourished children younger than 5 years (weight or age)	4.9	5.9
Proportion of 1-year-old children immunized against measles	31.7	32.3
Proportion of 1-year-old children immunized against tuberculosis	81.5	83
Proportion of 1-year-old children immunized with three doses of DPT vaccine	86.8	87.5
Adult literacy rate	72.9	76.5
Net enrollment rate in primary school	95.6	89.3
Net enrollment rate in secondary school	87.8	87.6

There is even less data available on regional disaggregation of gendered data on socioeconomic conditions, to allow us to identify socioeconomic disparities relating to gender in the Ayeyarwady Basin. However, as we have seen from the gender-specific demographic data, there are likely to be large and significant variations between regions and states. Table 123 illustrates differences in economic activity and unemployment between different geographical areas of the Ayeyarwady Basin and nationwide. In terms of the economically inactive population aged 15 - 64, approximately 35% more women are economically inactive than men nationally. This gap is widest in Bago (43.4%), Ayeyarwady (42.1%), Kachin (39.8%), and Yangon (35.4%). Unemployment rate disparities are much lower, with nationally only 0.2% more women being unemployed than men. This disparity is highest in Bago (1.1%), Kachin (0.8%), and Ayeyarwady (0.6%), but is lowest in Yagon (-0.4%).

Table 123 - Gender disparities pertaining to employment and unemployment in Ayeyarwady Basin regions and states and nationally 2014

(UNFPA, 2017)

Area	Economically inactive population - gender gap	Unemployment rate gender gap
Urban	-	-0.2
Rural	-	0.4
Kachin	39.8	0.8
Chin	23.8	-1.2
Sagaing	28.4	0.5
Bago	43.4	1.1
Magway	28.3	0.5
Mandalay	33	0.1
Yangon	35.4	-0.4
Shan	22.2	-0.2
Ayeyarwady	42.1	0.6
National	34.7	0.2

a) Gender and agriculture

As noted elsewhere, agriculture remains the main source of employment in Myanmar and the Ayeyarwady Basin. Gendered differences in access to agricultural resources and patterns of livelihood activity in the sector are therefore important. The agricultural census in 2010 illustrated important differences in access to land for FHH, whereas 98% of male-headed households had access to agricultural land, which declined to 61% for FHH (ADB, 2016). The land holdings of FHH also tended to be smaller, at 2.1 ha spread over 3.7 parcels, compared to 2.6 ha spread over 4.2 parcels for male-headed households (ADB, 2016). There are also questions surrounding the security of land tenure for women. While women have equal rights to property under the 2008 Constitution, there is no legal guidance on how, in practice, women can defend land use rights in cases of divorce or the death of a spouse. Customary practices do not accord equal rights to women and men over land ownership. Land title is registered only in the name of the household head, meaning effectively in most cases wives are not recognized as joint land-owners (ADB, 2016).

There is a gendered division of labour in agriculture. Women are generally more responsible for most tasks related to crop cultivation, including planting, weeding, transplanting, harvesting, threshing, post-harvest activities, and the sale of produce. Women are also responsible for tasks related to managing the household including domestic care roles (the children, sick, and elderly), meal preparation, firewood collection, and provision of drinking water. Men tend to be involved in heavier tasks including ploughing, land preparation, felling trees and clearing land, and provision and maintenance of agricultural infrastructure (flood protection and irrigation works, fencing, etc.). Women spend much more time on domestic tasks than men, which they manage simultaneously with their other agricultural roles (ADB, 2016). It should be noted that there is limited information as to the impact of the modernization of agriculture. Mechanization is likely to have a significant impact on the availability of rural employment and gender roles in agriculture, which will need to be considered in the future.

b) Education and training

Female literacy rates are estimated for people aged 15 and upwards, and are estimated to be 86.9% compared to 92% for males (in 2015). In general, primary and secondary school enrollment for males and females have reached parity (ADB, 2016). However, good national performance masks important economic and regional disparities. Table 124 highlights the regional disparities within the Ayeyarwady Basin.

This data shows that generally, at the national level a slightly greater proportion of females have not had any formal education. Chin State (21.6%) in particular stands out with a much high proportion of females to males without formal education, although the figure is also significantly higher than the national average in Shan State (10.1%), Mandalay (6.7%), Sagaing (5.6%), and Kachin (5.6%). Similarly, fewer females have had primary education across most of the country, with the exception of Yangon (2%), Ayeyarwady (0.2%), and Bago (0%). Again, Chin State appears to harbor the highest gender disparity (at -4.6%). Nationally, a lower proportion of females have also completed secondary education with a gender gap of -1.8%. Again, patterns differ across the Ayeyarwady Basin, with Chin State (-3.6%), Yangon Region (-3.1%), Mandalay Region (-2.1%), and Magway Region (-2%) showing the highest levels of gender disparity.

Table 124 - Gender gap education indicators in Ayeyarwady Basin regions and states, and national 2014

(UNFPA, 2017)

Area	Gender gap (over 25s, various dimensions) (% female - % male)		
	No education	Primary only	Upper secondary completed
Urban	3.9	-	-
Rural	6.3	-	-
Kachin	5.6	-0.6	-1.1
Chin	21.6	-4.6	-3.6
Sagaing	5.6	-0.7	-1.8
Bago	4.4	0	-1.7
Magway	4.6	-0.9	-2
Mandalay	6.7	-0.2	-2.1
Yangon	2.7	2	-3.1
Shan	10.1	-2.1	-0.6
Ayeyarwady	3.7	0.2	-1.3
National	5.5	-0.1	-1.8

Despite the relatively small gender differences in access to education, these achievements do not match post-education employment data, highlighted by much lower female labour force participation rates, continuing pay discrepancies, and the absence of women in senior level posts (ADB, 2016).

11.3.4 Conclusion

While we have endeavored to draw together the rather sparse data relating to gender inequalities relevant to the Ayeyarwady Basin, the overview of the data presents only a partial picture. Measures to address persistent gender inequalities will require, in the first instance, a better understanding of the problem. This in turn implies the need for the collection of gender disaggregated data for key indicators in the Ayeyarwady Basin. The collection of gendered data can also be used to raise awareness of the importance of gender for Ayeyarwady Basin development, and thus start the long road to institutional capacity building for the development and effective realization of policies and programmes which target these chronic inequalities.

11.4 Peace Building

11.4.1 Introduction

Civil conflict and peace building are unavoidable and defining issues in some areas of the Ayeyarwady Basin, with significant implications for patterns of economic and social development. This section seeks to highlight areas of the basin where conflict is significant and emphasizes its interaction with other themes relevant to river basin planning. This section does not seek to investigate the peace process or ongoing conflict in the basin in any great detail. Rather it seeks to briefly establish and understand the historical context for the civil conflict in the Ayeyarwady Basin, understand the current patterns of conflict, and then relate these to broader issues of socioeconomic development in the Ayeyarwady Basin.

To do this, Section 11.4.2 looks at the broad historical context from 1948 to the present, Section 4.3 looks at indicators of the distribution of conflict in the basin, and Section 4.4 looks at the implications of conflict in the Ayeyarwady Basin for socioeconomic development. This section draws heavily on the analysis of conflict recently conducted as part of the IFC assessment of HP development in Myanmar (ICEM, 2017).

11.4.2 Historical context

The emergence of civil conflict in Myanmar and the Ayeyarwady Basin has broadly been the result of a failure to establish governance arrangements that can satisfactorily incorporate the interests of a range of ethno-political groups. Disagreements have turned on the degree of centralization of power, claims to territory and settlements, and governance autonomy (ICEM, 2017). The subject of contestation between different groups and the state has been varied. It includes the right to self-determination, cultural and religious freedom, access to benefits from resources, and the authority to raise taxes and provide services. The details of disputes vary in geographical scope, in the extent of demands and in terms of support. Conflict intensity has also varied widely (ICEM, 2017).

The roots of civil conflict in Myanmar can be traced back to before independence. However, the Panglong Agreement of 1947 in which Chin, Kachin, and Shan leaders agreed to join the Union of Burma was based on guarantees of equality, limited autonomy, and the right to secede. Other ethnic groups did not participate in the agreement. Following independence in 1948, the failure of the constitutional settlement to meet the aspirations of groups excluded from the Panglong agreement, and somewhat later those party to it, led to the development of armed insurgencies. The military took power in 1962 as a response to the perception of the risk of national disintegration due to ethnic claims to autonomy (see Chapters 3 and 4). At this time, power was centralized and the governments in the ethnic state were abolished. This centralization of power continued with the drafting of a new constitution in 1974, which served to emphasize the absence of political and administrative autonomy in the ethnic states. At the same time that conflict increased, the number of armed ethic groups increased, as did the numbers of fighters drawn to these groups (ICEM, 2017).

A popular uprising suppressed by the military in 1988 consolidated its control again under the State Law and Order Restoration Council (SLORC). Elections in 1990 saw the NLD win 80% of the seats, but the results were annulled and SLORC remained in power. In the period between 1988 and 2008, SLORC was able to reach 31 ceasefire agreements with EAGs including a number in the Ayeyarwady Basin, some of which provided for the creation of autonomous territories. The process of the development of a new constitution was started by SLORC in 1993, but was abandoned in 1996 when the NLD refused to take part. A constitutional convention was reconvened in 2004 without the NLD, and attempts to press for devolved assemblies by ethnic political and ceasefire groups were rejected. In 2008 the new constitution was adopted, but still maintained centralized decision making, falling short of ethnic minority aspirations to autonomy (ICEM, 2017).

From 2011 the government began comprehensive efforts to reach peace agreements with ethnic armed organizations, resulting in the signing of a number of bilateral ceasefires. These were to some extent superseded by the Nationwide Ceasefire agreement, which was negotiated between 2013 and 2015. This was supposed to represent an inclusive process of political dialogue that would enable the causes of ongoing civil conflicts to be addressed. However, only approximately half of the ethnic-armed organizations signed the agreement, the substance of which is overwhelmingly concerned with military issues. Other ethnic armed groups remain in dialogue with the government through the United Nationalities Federal Council, which is seeking additional points of agreement. Between August 2016 and June 2017, three national level peace conferences were held as part of this process. These Panglong conferences have a broader scope than the ceasefire agreement and are intended to negotiate political, social, economic security, and natural resource issues. The process is yet to produce substantive outcomes (ICEM, 2017).

11.4.3 Current geography of conflict in the Ayeyarwady Basin

Despite the progress made in the peace process, there has been a distinct increase in violence since 2011, particularly in the Ayeyarwady Basin. In Kachin State a 17-year ceasefire agreement between the Myanmar army and the KIA broke down. This has resulted in an escalation of violence in the north of the Ayeyarwady Basin. The renewed conflict has been heavy at times, involving aircraft and artillery. Estimates suggest that approximately 100,000 people have been displaced in Kachin State and Shan State. While the army has been able to take a large amount of territory formerly held by the KIA, they have been confronted by Northern Alliance allies that maintain a significant degree of influence in northern Shan State and southern Kachin State (ICEM, 2017). Figure 197 shows data on estimated deaths from armed conflict between 1990 and 2015 in the Ayeyarwady Basin, with widespread recent conflict across Kachin and northern Shan states apparent.

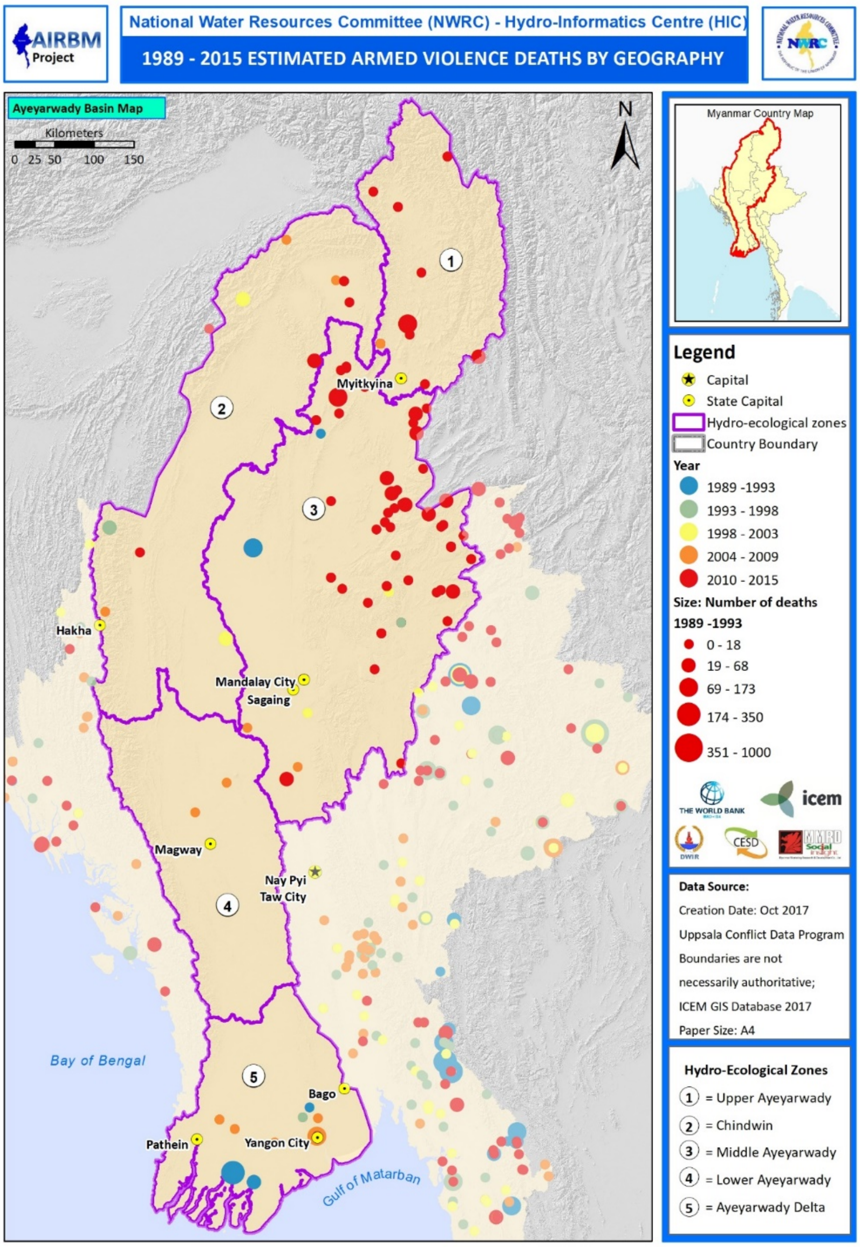


Figure 197 - Estimated deaths due to armed violence 1990 - 2015 in the Ayeyarwady Basin

11.4.4 Implications for socioeconomic development

The exploitation of natural resources in conflict areas in the north of the Ayeyarwady Basin has been an important driver of conflict. The production and illegal export of valuable resources such as timber, jade, gold, and other precious stones as well as narcotics have both been an important means of financing armed groups in the region and have acted as an incentive for the military to exert its control.

The development of ceasefire agreements during the 1990s allowed an increase in economic activity in Kachin and northern Shan states. In particular, developments included increased investment in capital intensive sectors such as HP and mining, the development of large agricultural and agro-forestry concessions, and the development of trade corridors with the PRC. The Shwe gas pipeline, which passed through Shan State was also enabled by a more peaceful climate, and a number of HP concessions in the region would not have been feasible without the ceasefire. At the same time, the military took the opportunity to consolidate their position in Kachin through a significant increase in troop number and facilities in the territory (ICEM, 2017).

On the other hand, ethnic minorities living in these regions have raised concerns regarding the unchecked exploitation of resources. These include land appropriation for large agricultural concessions (see Section 11.2), HP, and mining activities. These activities are often coupled with illegal timber extraction and smuggling. The rapid expansion of mining for gold (particularly using hydraulic mining techniques) and jade have had widespread environmental and social consequences (see Section 7 on mining). Militarization of the state has also come with intimidation and harassment of the people. Ethnic minorities are aggrieved by these developments as they see very little benefit from what they regard as their resources, though they have to suffer the consequences of their unchecked exploitation (ICEM, 2017).

11.5 Conclusion

As pointed out in the introduction to this section, there are a number of reasons why rising inequality in the Ayeyarwady Basin should be considered a development issue, related to fairness and social cohesion, poverty reduction, and economic growth. The discussion of livelihoods in the Ayeyarwady Basin (Chapters 3 and 4) presented analysis based on the available census data that highlighted geographical disparities in access to services (electricity, sanitation, water supply, housing, and transport) and in terms of poverty. This analysis served to emphasize the continuing importance of geospatially realized inequalities. The spatial pattern this presented is familiar from studies across the region and globally, remote communities on the economic periphery tend to have higher levels of poverty and economic deprivation. In the Ayeyarwady Basin context, this includes upland areas such as Chin State, some areas of Sagaing Region, Kachin, and some areas of Shan State. Of the lowland areas, the maritime periphery of the Ayeyarwady Delta also stands out.

Aside from the obvious geographical inequalities this section has examined three cross-cutting themes related to and reflective of equity and distributional issues that persist within the Ayeyarwady Basin, namely land, gender, and conflict.

In the predominantly agrarian context of rural Myanmar land, or rather propriety rights over land, frequently represent the most valuable asset owned by households. Even in urban areas, with limited asset alternatives, land and real estate often represent households' main asset. Inequalities in access to land or the ability of land holders to effectively exercise propriety rights over land are associated with adverse distributional outcomes. Such disparities are also an important indicator of broader patterns of inequality present in society as a whole. Addressing inequities in access to land, including regularizing land holdings particularly for communal land holdings, and ensuring proper resettlement and compensation is in place in cases of land acquisition for urban or infrastructure development, are policy priorities for government.

Similarly, inequality of opportunity and outcome related to gender remain pervasive. This is reflected in access to education, economic opportunities, health and family planning services, and differential treatment of men and women in employment. Policy can start to address some of these issues, but a prerequisite for effective intervention must be a better understanding of gender disparities, their causes, and effects. Gathering adequate gendered data is a priority for the design of interventions to address gender inequalities.

Finally, we have also included a discussion of conflict in this section, as to a large degree ongoing civil conflict the Ayeyarwady Basin is a concrete reflection of inequitable or unfair societal and political outcomes real or perceived. Often the perception of inequality relates to access to valuable natural resources in contested areas. At the same time, conflict and the militarization of these areas effectively allows the appropriation of these natural resources by armed groups, exasperating inequitable access. People living in these areas are often forced from their land and homes, again reinforcing established patterns of inequality between different social groups. In the case of civil conflict, the resolution in the first place must be political, although a more equitable distribution of resources is likely to play an important part in any peace process.

12 CASE STUDIES

12.1 Introduction

The team developed three short case studies to draw attention to the unique socioeconomic characteristics or trends in the Ayeyarwady Basin related to the key sectors in the Ayeyarwady Basin. The case studies allows for a more in-depth understanding of how bio-physical and socioeconomic systems interact within the Ayeyarwady Basin. They will also be important as a means of verifying the geospatial, trend, and livelihoods analysis conducted in the demographic and sectoral baselines in Sections 1 - 10. The case studies will use a mix of qualitative and quantitative data to build a cross-cutting, multi-dimensional picture of a specific context related to the key economic sectors included in SOBA 5. The case studies will also make full use of secondary sources (such as government statistical data and donor reports) and mapping, as well as evidence gathered through stakeholder consultations and interviews.

In discussions with the PMU and other SOBA packages during the inception workshop, the following three case studies were selected:

1. **Thapanzeik HPP** - Thapanzeik HPP, situated on the Mu River in the Sagaing Region and completed in 2001, is approximately 6 km long, making it one of the largest dams in Southeast Asia. It is a multi-purpose dam, providing water for irrigation and electricity for the nation's socioeconomic development. The dam enables year-round irrigation of over 200,000 ha with feeder canals extending to eight townships. It has 30 MW of installed HP capacity comprised of three 10 MW turbines. This case study investigates the operation of this project with an emphasis on understanding water resources management for multiple uses and to determine the benefits and impacts for the Kyun Hle and Shwe Bo townships.

2. **Sand mining** - Sand mining in the Ayeyarwady Basin represents the main source of sand and aggregates used in the construction industry in Myanmar. Effectively uncontrolled conduct of sand mining in the Ayeyarwady Basin and unsustainable extraction of materials from rivers could change the morphological processes in the basin and pose significant problems, such as increased erosion, increased channelization of the river, and issues for deltaic stability. SOBA 3 is undertaking an assessment of the supply side of sand and sediment extraction from selected locations in the Ayeyarwady Basin. SOBA 5 supplements this through the development of the case study, looking at the socioeconomic drivers of sand and sediment use in Myanmar. Following the SOBA draft review workshop, these two case studies on supply and demand side could be combined.

3. **Hardwood certification** - Managing deforestation and ensuring hardwood production remains at a sustainable level will be an important part of developing a sustainable approach to Ayeyarwady Basin management. This case study seeks to develop a better understanding of the trade in hardwood from the Ayeyarwady Basin with a particular focus on understanding the certification processes and the role it can play in strengthening the management of the sector.

12.2 Thapanzeik Hydropower Project Case Study

The SOBA 5 team conducted field visits for the Thapanzeik HPP case study in August 2017, which included the following activities:

- Key informant interviews (KII) with Department of Agriculture, IWUMD, Department of Fisheries and Electric Power Supply Enterprise in Monywa, Sagaing Region;
- KII with the Plant Manager at Thapanzeik HPP;
- KII with General Administration Department (GAD) at Kyun Hla Township;
- KII with GAD at Shwe Bo Township;
- Focus group discussion (FGD) with Kyun Hla Township departments;
- FGD with Ywa Thi Village and Kyi Kone villages in Kyun Hla Township; and

- FDG with Chi Pa Village in Shwe Bo Township.

12.2.1 Overview

Thapanzeik HPP is a multipurpose HPP owned by MOALI. Located on the Mu River it incorporates a 30 MW HP plant. It joins the Ayeyarwady from the west approximately 40 km downstream of Mandalay City. Located in the Kyun Hla Township in Sagaing Region, the construction of the project began in 1996 and was completed in 2001 (Figure 198). The 33 m high dam created the largest man-made reservoir in Myanmar to date with an inundation area of 397 km^2.

Figure 198 - Thapanzeik dam

A diversion weir approximately 11 km downstream of the dam diverts water for irrigation on both banks of the Mu River. Although the Ayeyarwady has not been fully utilized for irrigation in the CDZ, its tributary, the Mu River, has been used for this purpose since the 9th century. The Mu Valley Irrigation Project is among the largest in the country. It permits the dry-season cropping of corn, peanuts, sesame, wheat, cotton, millet, and other dry crops. About one-sixth of the total rice grown in Myanmar comes from the irrigated areas of Mandalay, Sagaing, and Magwe divisions.[66] Designated as a multi-purpose HPP, the Thapanzeik project was designed and built with two main objectives: 1) to generate electricity to feed into the national grid, and 2) to provide irrigation water for farmers in the area.

a) Power production (GWh)

The annual production capacity of the project is 117.2 GWh according to the design, however from 2002 - 2003 to 2016 - 2017 the plant has regularly exceeded annual production targets (Table 125). In 2016-2017, the actual production was 163.89 GWh, well above the target production of 110.5 GWh. The power plant is connected to Ngapyadaing sub-station by a 53 km long 132 kV transmission line.

Table 125 - Power production (GWh) from 2002 - 2003 to 2016 – 2017

(Thapanzeik Plant Operator)

Fiscal year	Production (GWh)
2002 - 2003	147.53
2003 - 2004	93.38
2004 - 2005	129.2

[66] https://www.britannica.com/place/Irrawaddy-River

Fiscal year	Production (GWh)
2005 - 2006	115.37
2006 - 2007	113.02
2007 - 2008	181.87
2008 - 2009	162.22
2009 - 2010	151.78
2010 - 2011	148.02
2011 - 2012	143.91
2012 - 2013	112.69
2013 - 2014	77.56
2014 - 2015	107.49
2015 - 2016	136.98
2016 - 2017	163.89

b) Provision of irrigation water for farmers

The irrigation scheme connected to the reservoir has increased the area of irrigated land in some districts in the Sagaing Region. Table 126 below highlights that 88.5% of the cultivated area (316,470.5 ha) in the Shwe Bo District, and 9.1% of the cultivated area in Kant Ba Lu District (32,678.4 ha), is covered by the irrigation scheme. The irrigation scheme also covers the cultivated area of Yin Mar Pin (1.7%), Ta Mu (0.2%) and Ka Lay (1.7%). Generally, the other districts have a much higher percentage of rain-fed agriculture than irrigated agriculture. Other sources of water for agriculture in Sagaing Region include river pumping and groundwater. River pumping is mainly used by the districts along the Ayeyarwady River; Monywa (4,141.6 ha of cultivated land), Sagaing (3,763.6 ha), Yin Mar Pin (937.7 ha), and Katha (100.8 ha).

Table 126 - Total irrigated area in Sagaing Region by district

(Sagaing, Department of Agriculture)

District	Cultivated area (ha)	Irrigation scheme		River pumping (ha)	Ground-water (ha)	Total irrigated area		Rainfed area	
		ha	%			ha	%	ha	%
Sagaing	191,403.5	1,530.1	0.4	3,763.6		5,293.7	1.4	186,109.8	12.3
Monywa	269,864.9	110.9	0.0	4,141.6	943.3	5,195.8	1.4	186,109.8	17.5
Yin Mar Pin	240,057.3	6,040.3	1.7	937.7		6,978.0	1.9	264,669.1	15.4
Shwe Bo	472,248.7	316,470.5	88.5	0.0		316,470.5	86.1	233,079.3	10.3
Kant Ba Lu	204,867.8	32,678.4	9.1	0.0		32,678.4	8.9	155,778.2	11.4
Ka Tha	244,395.1	0.0	0.0	100.8		100.8	0.0	172,189.4	16.2
Kalay	106,259.2	321.7	0.1			321.7	0.1	244,294.4	7.0
Maw Lite	44,956.6	0.0	0.0			0.0	0.0	105,937.5	3.0
Ta Mu	32,947.1	565.8	0.2			565.8	0.2	44,956.6	2.1
Khan Tee	54,050.3	0.0	0.0			0.0	0.0	32,381.3	3.6
Nar Ga	15,309.7	0.0	0.0			0.0	0.0	54,050.3	1.0
TOTAL	**1,876,360.2**	**357,717.7**	**100.0**	**8,943.6**	**943.3**	**367,604.6**	**100**	**1,508,755.6**	**100**

The irrigation scheme associated with the Thapanzeik reservoir provides water for 369 village tracts, approximately 212,943 farmers, and covers an irrigated area of 198,978.8 ha (Table 127).

Table 127 - Irrigation scheme and irrigated area

(Department of Agriculture)

Name of irrigation scheme	District	Township	Village tracts	Farmers	Irrigated area (ha)
1. Kar Bo Weir, Shwe Bo Canal	Shwe Bo	Kant Ba Lu	2	233.0	283.3
	Shwe Bo	Khin Oo	24	9,829.0	11,933.8
	Shwe Bo	Shwe Bo	48	13,314.0	31,105.4
	Shwe Bo	Wet Let	48	30,493.0	38,674.6
	Sagaing	Sagaing	5	53,869.0	81,997.1
TOTAL			**127**	**107,738.0**	**83,623.5**
2. Kar Bo Weir, Ye Oo Canal	Shwe Bo	Ye Oo	25	11,522.0	10,611.7
	Shwe Bo	De Pe Yin	44	27,144.0	32,353.8
	Monywa	Ayar Taw	9	2,094.0	3,585.1
Ye oo Canal total			78	40,760.0	46,550.6
Kar bo Weir total			205	148,498.0	130,174.1
3. Kin Tet Weir Left Canal	Shwe Bo	Kant Ba Lu	26	8,628.0	12,958.9
	Shwe Bo	Khin Oo	22	3,907.0	10,420.7
	Shwe Bo	Shwe Bo	11	1,046.0	2,967.6
Left canal total			59	13,581.0	26,347.1
4. Kin Tet Weir Right Canal	Shwe Bo	Tant Say	36	24,312.0	17,499.4
	Shwe Bo	Ye Oo	33	15,554.0	13,071.4
	Shwe Bo	De Pe Yin	19	4,279.0	7,307.8
	Monywa	Ayar Taw	6	3,438.0	1,252.9
	Monywa	Bu TaLin	11	3,281.0	3,326.1
Right Canal total			105	50,864.0	42,457.6
Kin Tet Weir total			164	64,445.0	68,804.7
TOTAL			**369.0**	**212,943.0**	**198,978.8**

c) Tale of two townships

The dam has largely achieved its objectives for power production and increasing irrigated area (ha), however it became apparent during the KIIs and FGDs that the benefits flowed to the Shwe Bo Township, while Kyun Hla Township had borne the impacts of construction and operation of the project. Kyun Hla is located directly in the reservoir area, while Shwe Bo Township is located downstream of the reservoir (Figure 199). The following sections compare distribution of the benefits and impacts of the Thapanzeik HPP for Shwe Bo and Kyun Hla. It is the tale of two townships.

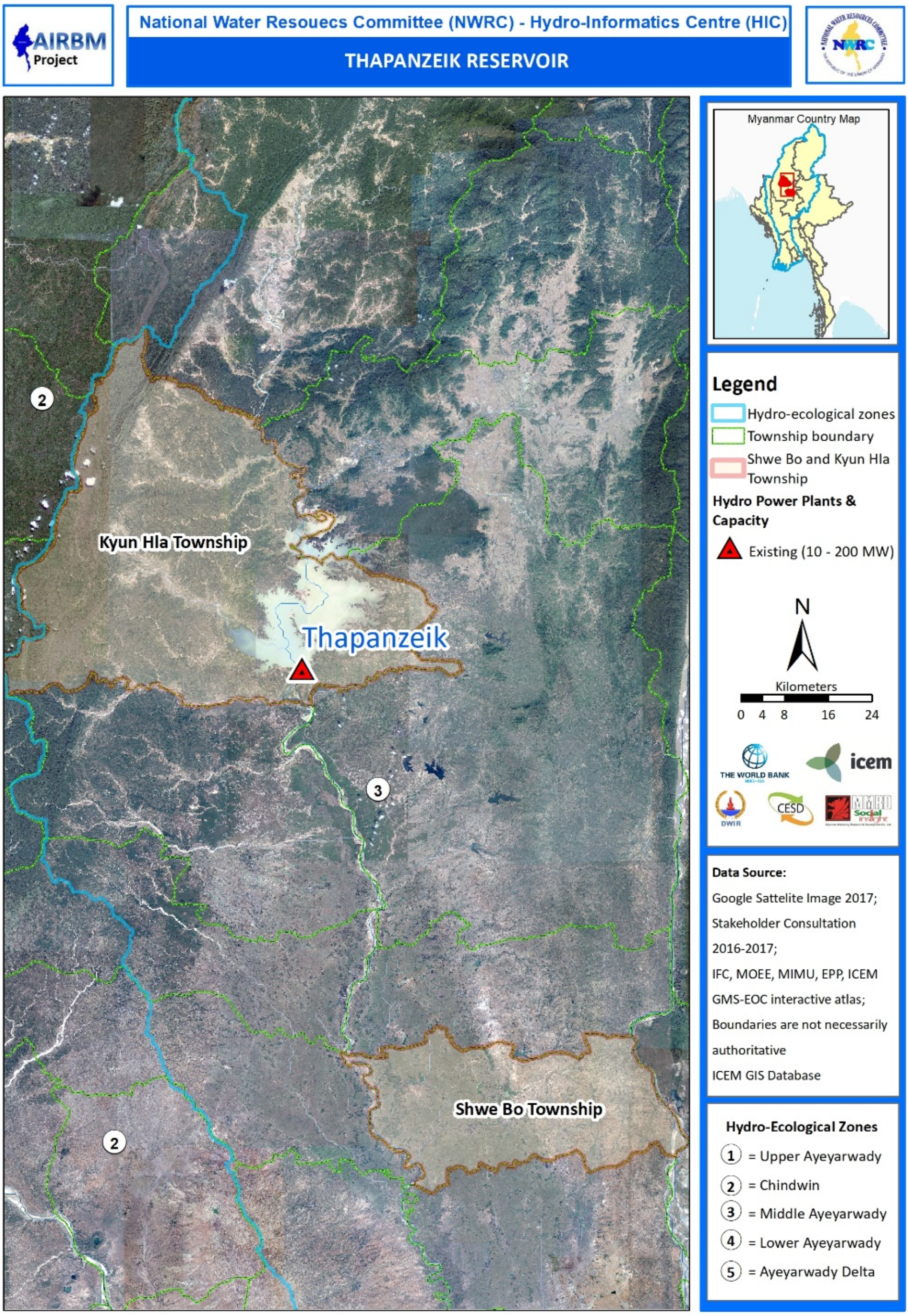


Figure 199 - Thapanzeik HPP in relation to Kyun Hla and Shwe Bo townships

12.2.2 *Shwe Bo Township*

Located downstream of the Thapanzeik Dam, Shwe Bo Township did not encounter any of the common negative impacts, such as relocation or loss of agricultural land, due to construction of the project. Instead, Shwe Bo received the socioeconomic benefits gained by the availability of water for irrigation provided by the dam. Chi Pa Village, with 1,321 households and a population of 5,627 people, is one of the village tracts with increased access to water for irrigation and access to electricity.

a) Agriculture

The Kar Bo and Kin Tet weirs provide irrigation water for summer paddy in Shwe Bo Township, with the total irrigated areas amounting to nearly 198,978.8 ha (Table 127). Before Thapanzeik Dam was constructed, farmers relied solely on rainfall to grow their crops. Since they did not have storage capacity, farmers faced water shortages during dry seasons or in years with low rainfall. The only crop they could afford to grow was rain-fed rice (mono-cropping).

After the dam started operation, water for irrigation was available year-round and even in drought years, though the storage capacity of Thapanzeik Dam was still approximately 3,700,440 megalitres. In addition to rain-fed rice, farmers could also grow irrigated rice and other cash crops such as pulses (pigeon pea, chick pea, and green gram) and oil seed crops (sesame, groundnut, and sunflower). Water availability from the dam also helped to increase yield and cultivation areas (ha). The yield from monsoon rice is approximately 80 - 90 baskets per acre, and summer rice yields approximately 100 baskets per acre. In Chipa Village tract, farmers were able to improve crop yield to double that of village tracts in Kyun Hla Township, located upstream of the dam.

b) Electricity access

Communities in the Shwe Bo Township also benefited from the electricity generated by Thapanzeik Dam. Because electricity is not distributed directly from the power plant to the township but through the national grid, electrification took a few years after construction to materialise. Households can now use electricity for cooking, lighting, and weaving machines. Farmers are able to use electricity for irrigation pumps and to operate rice mills to increase the quality of rice produced. Increased productivity and improved quality of produce has led to increased income. Now, people living in the township and mostly dependent on agriculture and traditional weaving do not have to migrate to other townships or cities for employment. However, the electricity provided is at low voltage, preventing the development of any industrial activities that need high voltage lines.

c) Challenges for agricultural development remain

Despite Thapanzeik Dam providing much needed water for year-round irrigation, farmers in Shwe Bo Township face several challenges to improving agricultural production. Farmers still have strong belief in traditional practices and they are slow to adopt new technologies. Extension workers have difficulty providing training in the technology and best practice techniques available, due to the difficulty of accessing villages. Long-distance training opportunities are limited due to the lack of necessary audio and visual facilities. The lack of capital investment and the inappropriate use of the capital that has been provided present additional obstacles. Loan amounts are often not enough for farmers to purchase additional inputs such as fertilizer and pesticide (as much as 1500,00 kyat per acre for rice and 40,000 kyat per acre for other crops). Even when securing the loans, some farmers use them for other purposes, wasting the valuable capital for agricultural input.

Contact farmers, who are responsible for disseminating qualified and purified seeds from government seed farms to farmers in the community, often sell these as grain (for eating) as a source of income. As a result, in the growing season, farmers do not have seeds to plant and have to purchase this from uncertified sources, with seed quality unchecked. Inappropriate handling of agrochemicals, labour shortages, and a lack of systematic farm roads are other barriers to agricultural development in the township.

12.2.3 Kyun Hle Township

The Kyun Hla Township has suffered severe loss of livelihood-means and income due to displacement and resettlement during the construction of Thapanzeik in 1996. Despite an improvement in some social services, the village tracts in Kyun Hla do not have access to irrigation schemes.

To analyze the trends of the water environment, socioeconomic livelihood, infrastructure, flooding, and electricity from 1990 - 2017, a village timeline was developed during a participatory activity at the FGD at Ywa Thi Village (Table 128).

Table 128 - Timeline for Ywa Thi Village from 1990 - 2017

Items	Year			
	1990	1996	2010	2017
Water environment	Access to water for drinking and domestic use from Mu River and wells in the rainy season	Water supply from dam, poor taste and quality	Sufficient water supply from drilled wells, rainwater retaining ponds for livestock	Sufficient water supply from drilled wells, rainwater retaining ponds for livestock
Socioeconomic livelihood	Lowland rice and other cereal crops such as sesame, local maize, and peanut are grown on alluvial land Good yield due to sufficient water supply from Mu River and fertile land Good economic condition	Village relocated due to Thapanzeik Dam construction Cropping pattern changes from irrigated farming to rain-fed farming Low crop yield due to poor quality of land in the resettled area Decreased income	Main livelihoods are agriculture and fishing Low crop yields as compensated lands have low fertility Poor socioeconomic conditions Increased in-country migration for employment, i.e., border area and Hpa Kant Township	Main livelihoods are agriculture and fishing Low crops yield as compensated lands have low fertility Poor socioeconomic conditions Increased in-country migration for employment, i.e., border area and Hpa Kant Township
Transportation	Bullock cart is used to commute to Kyun Hla City	No adequate transportation, education or health care after four years of resettlement	Improved transportation system	Improved transportation system
Education and health care	Limited number of schools		Increased number of primary and middle schools Health care improvement	Increased number of primary and middle schools Health care improvement
Flooding	Flooding on farmlands from Mu River in the rainy season	No flooding	No flooding	No flooding
Electricity	No electricity	No electricity	Electricity access	

The impacts on and benefits to agriculture, displacement, and resettlement are summarized in the following sections.

a) Agriculture

The main source of income in Kyun Hla Township is the cultivation of seasonal crops on rain-fed land. Unlike Shwe Bo Township, the farmers do not have access to any of the irrigation services that the Thapanzeik Dam provides even though it is closer to the dam. The impact of the dam has been negative for the agricultural sector as productive farmland was inundated.

During the resettlement period, some villagers received new lands in forest areas as compensation. However, these uplands are not as fertile and some are not even arable. Worse, they are not recognized as cultivable lands according to land use policy. As a result, farmers were not allowed to receive land use certificates for using these lands and were unable to access agricultural loans, which meant they could not purchase fertilizers to improve soil fertility. In addition, farmers still have to rely on rainfall, and multiple cropping is thus not feasible. These factors have contributed to a decline in agricultural yield in Ywa Thi, Kyi

Kone, and other villages in Kyun Hla Township since relocation and the number of farmers has decreased from 9,000 to 6,000. Food security also emerged as a big issue for the community in Kyun Hla Township.

b) Displacement and resettlement

Due to dam construction, 60 villages in Kyun Hle Township were relocated: 33 villages to the east of the dam and 27 villages to west. It now takes much more time to commute between the eastern and western parts of the township, especially in the rainy season.

Losing their agricultural lands, villagers have had to adapt to their new environment and find new ways of making a living. However, the livelihood options at the new locations were limited and approximately 20 villages refused to relocate. These villages have stayed around the reservoir area informally, and their names are excluded from the village list of GAD. The government does not recognize their existence and as a result, these villages cannot be provided with support such as agricultural extension or social services, leaving them more vulnerable to the impacts of the dam.

There have been benefits to the resettled communities. Villagers in Ywa Thi and Kyi Kone now receive better health care and transportation. Kyun Hla City can be reached by motorbike, unlike in the past when it could only be reached by boat across Pyaung Thwe Chaung, which was unsafe. There are also more primary and middle schools for children in the villages, and the villages no longer face the risk of flooding in the rainy season.

c) Electricity access

The Kyun Hla Township has also benefited from increased electrification. Before construction of the dam, the township had no electricity, but access has increased to 61.7% since the project commenced operations. The Thapanzeik Dam provides electricity directly to Kanbalu District, mainly to 19 resettled villages, while other villages get their electricity from the national grid. Electricity is used mainly for lighting, cooking, and the operating rice and oil mills, which in turn reduces the use of fuelwood, saves time and improves women's health.

12.2.4 Fisheries

Construction of Thapanzeik Dam has led to the loss of agricultural lands and a decline in fish capture from the Mu River. To compensate for this loss the reservoir is stocked with seedlings every year (Table 129).

Table 129 - (Sagaing, Department of Fisheries)

(Sagaing, Department of Fisheries)

Year	Fish species	Number of seedlings
2012 - 2013	Rohu, swamp barb	400,000
2013 - 2014	Rohu, swamp barb	500,000
2014 - 2015	Rohu, swamp barb, silver carp, tilapia	600,000
2015 - 2016	Rohu, swamp barb, silver carp	600,000

The reservoir has created opportunities for potential aquaculture development in the region. The Shwe Bo District has developed 945 fish ponds over 4,051.96 acres (1,625.2 ha) while the Kant Ba Lu District has developed 86 fish ponds over 589.43 acres (238.5 ha; Table 130).

Table 130 - Area and number of fish ponds in Shwe Bo and Kant Ba Lu districts

Shwe Bo District		
Township	**Fish pond**	
	No.	**Area (Acre)**
Shwe Bo	541	2,748.37
Khin Oo	258	637.6
Wet Let	94	506.38
Ye Oo	26	85.69
De Pe Yin	23	35.64
Tant Say	3	2.28
TOTAL	**945**	**4,015.96**
Kant Ba Lau District		
Township	**Fish pond**	
	No.	**Area (Acre)**
Kant Ba Lu	78	411.8
Kyun Hla	8	177.63
TOTAL	**86**	**589.43**

There are further opportunities for both culture-based, capture and reservoir fisheries in the Thapanzeik area. However, the legal frameworks of different government agencies create a barrier to reservoir fisheries. While the fisheries law allows for fishing in all water areas including reservoirs, the laws of the irrigation department prohibits fisheries in reservoirs. Consequently, farmers only adopt these practices informally, and the potential has not been exploited to the full extent. The Department of Fisheries in Sagaing Region also reported that illegal gold mining in the upper part of the reservoir is impacting water quality and causing increased sedimentation. The Sagaing regional government officially banned the gold mining activities at the end of August.[67]

12.2.5 Conclusion

The Thapanzeik HPP has achieved its objectives as a multi-purpose project by providing electricity to the national grid and increasing irrigated area in some townships in the Sagaing Region. However, the comparison of the Kyun Hla and Shwe Bo townships indicates that the benefits and impacts of the project were not equally distributed. Both townships benefited from increased access to electricity and social services, but resettled villages in the Kyun Hla Township were not provided with productive agricultural land or adequate compensation and the farmers do not have access to the irrigation services provided by the multi-purpose reservoir. This case study provides important lessons for the construction and operation of future multi-purpose projects in Myanmar:

- Design and siting of projects needs to minimize the number of villages affected by the reservoir area;
- Resettlement action plan needs be prepared prior to the construction phase and involve stakeholder consultation with all communities in project area;
- Affected communities should receive fair compensation for relocation and for loss of assets and livelihoods, such as financial compensation, provided agricultural land recognized by the law, or training for alternative livelihood options;

[67] https://www.mmtimes.com/news/villagers-decry-closure-gold-mines-near-dam-sagaing.html

- Livelihood transition is especially important for communities resettled in upland areas agriculture land is not as productive and swidden agriculture also often leads to forest loss and degradation;
- Enhanced coordination between multiple sectors, and region, district, township levels, and village tract representatives; and
- Effective monitoring and management is implemented through all phases of the project to ensure benefits are enhanced and impacts mitigated and managed.

12.3 Sand Mining

Since comprehensive economic reforms started in 2011, Myanmar's construction industry has been growing rapidly throughout the country. Concurrently, the demand for housing materials, including sand and gravel extracted from riverbeds, has increased rapidly. Most of these activities occur along the north to south flowing Ayeyarwady River, which passes through several major cities while also providing resources to cities nearby, including the largest commercial capital regions of Yangon, Mandalay, and Nay Pyi Taw. Elsewhere in developing countries, higher demand for construction resources have led to excessive and sometimes illegal mining, which have had severe and detrimental impact on the ecology of rivers. Weak capacity and overlapping jurisdiction between different levels of government agencies compound the problem.

12.3.1 Construction Booms and Busts in Yangon

With increasing urbanization and inward migration in Yangon metropolitan city, there is a huge demand for residential housing and commercial premises.[68] The Yangon Region had a population of only 3.2 million in 1973, and within forty years, the population has doubled to 7.4 million, according to the census of 2014 (Figure 200). This is in contrast with all other regions in Myanmar where each region's share of the national population has declined over the years, in favour of migration to the Yangon Region. As a consequence, the Yangon metropolitan region has been stretched to accommodate more people in the available land space, reaching a population density of 716, nine times higher than the national average (Census, 2014). The consequence of limited space has been a number of high-rise building projects launched since 2012, in an effort to accommodate more Yangon residents in the land available.

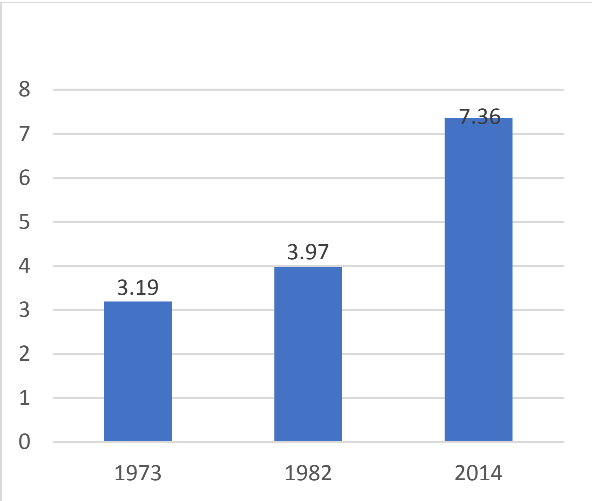


Figure 200 - Rising Population of Yangon Region (in million)

Since 2012, there has been a rapid increase of housing and commercial construction projects throughout the country. Following decades of dormancy due to lack of demand and investment, the construction sector experienced a boom at a growth rate surpassing that of the national GDP (Figure 201). By 2013, Myanmar was able to re-engage with the international donor community, attracting both overseas development assistance as well as foreign investment and boosting public investments in a number of infrastructure and

[68] MoC estimates that 4.8 million housing units will be needed by 2040 https://www.mmtimes.com/business/27200-housing-requires-2040.html

transport projects. For instance, Thilawa, a massive SEZ, was built in 2014 and the first phase completed within two years.

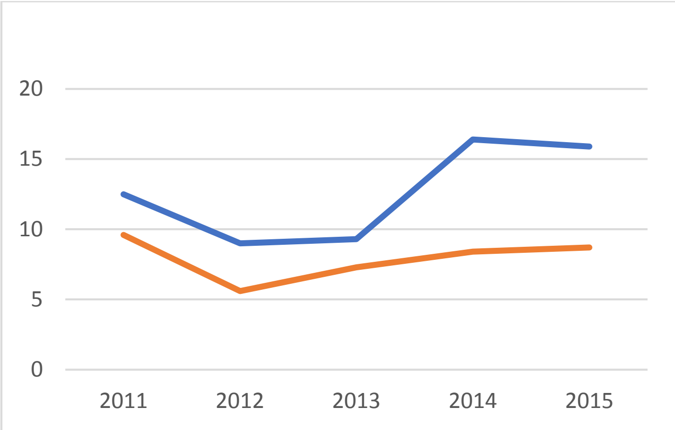


Figure 201 - Sectoral growth rate of construction sector (blue) persistently above national GDP growth rate (orange)

The construction boom led to high demand for sand and gravel from mining sites along the Ayeyarwady River and its tributaries near the Yangon Region. Sand and gravel mining licenses were allocated annually, by the Department of Water Resources and Improvement of River Systems (DWIR). Although sand mining was confined to tributaries of the Ayeyarwady River around Yangon, such as the Toe River, Hlaing River, Nga-moe-yeik Creek and Ton-tay canal areas, gravel mining licenses were permitted along the Ayeyarwady River in Ayeyarwady, Bago, and Magway Regions. During the housing boom in 2013, the demand for river aggregates went up rapidly, and the price of gravel in particular increased with nearly 50%, from 40,000 kyat per lot to 60,000 kyat in 2013,69 and continued upwards to reach 70,000 kyat by the end of 2015.[70] Many more licenses were issued by the district GADs in the townships along the Ayeyarwady River.

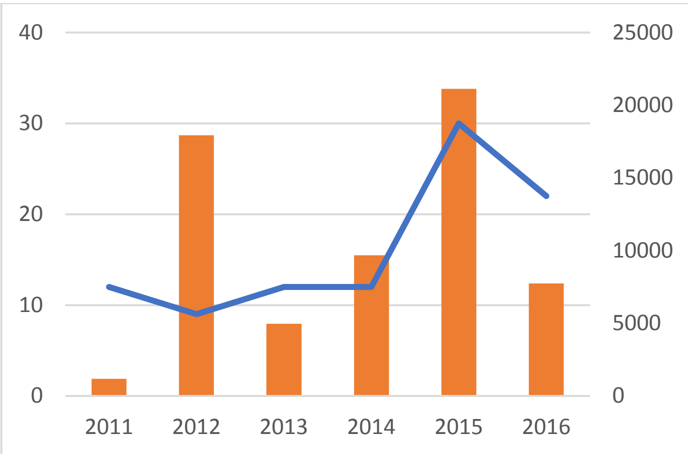


Figure 202 - Housing projects (blue) and number of room supply (orange) in Yangon

However, the boom seemed to have gone bust when the newly appointed Yangon regional government essentially put a brake on the growth of high-rise projects by tightening safety standards in 2016. In 2015, Yangon City Development Committee gave licenses to 30 housing projects that targeted to supply 20,000 rooms to the city. With the tightening of safety standards under the new government, the projects were reduced to 22 (Figure 202). However, many of high rise projects were scrapped, resulting in significant reduction in the targeted supply of rooms to only 7,000. The slump was so severe that many construction companies are said to be experiencing cash flow problems stemming from slow progress of their projects. As a result, gravel prices went down again to 38,000 kyats in the rainy seasons of 2016.

[69] Myit-ma-kha News. Gravel prices skyrocketing, 12 March 2013.
[70] Yangon Media Group, 'Gravel mining closures led to increase in its price.' 16 July 2017.

12.3.2 Public Outcry against Sediment Mining

In the meantime, the environmental NGOs and local communities used the opportunity of newly found civic space to voice strong opposition to the severe damaging effects of sand and gravel mining on river ecosystems. Their concerns mainly focus on disastrous riverbank erosion, the deterioration of water quality and fish habitat and stress or loss of flora and fauna communities. According to the environmental group Beautiful Land, several dozens of farmlands were destroyed by excessive sediment mining in Tha-paung Township, where gravel mining licenses were issued to seven contractors who were producing at an alarming pace of 100 t a day in a small location. As a result, the township's main water source, the Phyu creek, 'has lost its riverbed depth from 6 feet to 2 feet, almost unusable for local communities.'[71] The areas of the Ayeyarwady River system affected by sand mining are indicated in Figure 201.

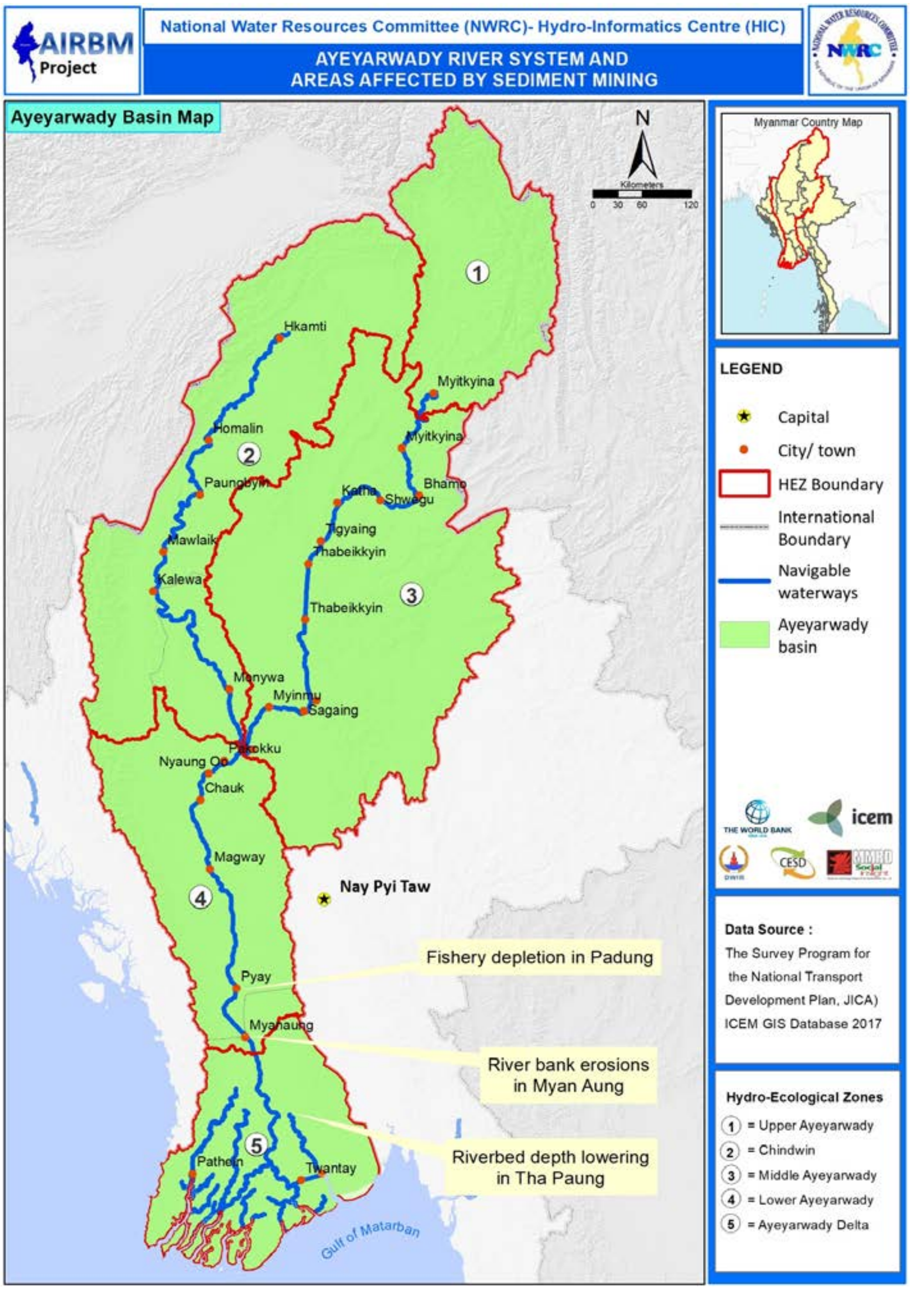


Figure 203 - Ayeyarwady River system and areas affected by sediment mining

In other townships such as Myan Aung and In-ga-pu, the local communities complained of riverbank erosion that caused not only the loss of agricultural cultivation areas, but also the relocation of families that lived

[71] Irrawaddy. '60 acres of paddy land were destroyed by gravel mining in Tha Paung.' 15 August 2014.

close to the river. In 2015, 180 households from Nyaung Kone Village in In-ga-pu Township as well as 100 households from Pe-ta-kwe Village in Myan Aung Township were relocated from their homes due to riverbank erosion. Although the DWIR will have to assess the extent of riverbank erosion affecting the communities living in the vicinity of river basins, there is no effective monitoring from the central government leading of illegal mining in various parts of the region, according to a local businessman.[72]

In Padaung Township, several groups of local fishermen organized a public protest on 28 February 2017 against the gravel mining in Pyay District, which depleted fresh water fishery resources for local communities. In Ywa-thit Village, almost the entire population depended on freshwater fisheries and approximately 150 households now faced difficulties to make ends meet. The incident prompted both regional governments of Bago and Magway to slow down the licensing procedures and reduce the number of allocated project sites in 2017. [73]

In response to growing public protests, a member of the Ayeyarwady regional parliament in June 2016 tabled the motion that DWIR should regularly monitor the impact of river mining on the adjacent communities and adopt stricter rules and tougher regulations to penalize the contractors who violate these. He received parliament-wide support for his motion, as he produced recent evidence of disastrous consequences of gravel mining in townships such as Kyankin, Myan Aung, In-ga-pu, Hinthada, and Zalun across the region.[74] The motion received attention from the regional government and put a brake on the licensing of gravel mining. As regional governments did not renew gravel mining, the prices of gravel escalated in 2017 to 80,000 kyats per lot, leaving some industrialists to speculate that it would reach 100,000 kyats by the end of the year.[75]

Table 131 - Gravel mining licences allocated in 2015

Location	Tributary	Waterway	Contractors	Lot allowed per contract	Total mining amount
1	Ngamoeyeik	Kyoe-kone	1	2,100	2,100
2	Hlaing	Myaung-ta-ka	2	2,100	4,200
3	Kokekowa	Taung-kyee thaung	3	2,100	6,300
4	Hlaing	Shwe-hlay-kyee thaung	1	2,100	2,100
5	Hlaing	Ka-lein-thaung	16	2,100	33,600
6	Kokekowa	A-nyar-su	1	2,100	2,100
7	Bago	Ma-htar-su thaung	2	2,100	4,200
8	Bago	O-bo thaung	13	2,100	27,300
9	Hmaw Wun	Pan-taw thaung	9	1,600	14,400
10	Hmaw Wun	Thaung Gyi	2	1,600	3,200
Total			**50**		**99,500**

Table 132 - Gravel mining licences allocated in 2016

Location	Tributary	Waterway	Contractors	Lot allowed per contract	Total mining amount
1	Ngamoeyeik	Kyoe-kone	2	1,600	3,200
2	Hlaing	Myaung-ta-ka	2	2,100	4,200
3	Kokekowa	Taung-kyee thaung	3	3,180	9,540
4	Hlaing	Shwe-hlay-kyee thaung	2	2,100	4,200
5	Hlaing	Ka-lein-thaung	11	2,100	23,100
6	Bago	Kayan Chaung	4	2,100	8,400
7	Toe	Thaung Thit	8	2,100	16,800

[72] Yatanarbon Daily. 'Relocation of villages in the wake of river bank erosions due to river mining.' 29 January 2016.
[73] 7Day News. 'Bago chief minister ordered strict adherence of sustainable mining in Ayeyarwaddy River.' 4 September, 2017.
[74] Mizzima. 'Member of Regional Hluttaw from Myan Aung constituency tabled the motion against gravel mining.' 6 June 2017.
[75] Yangon Media Group, Ibid.

Location	Tributary	Waterway	Contractors	Lot allowed per contract	Total mining amount
8	Toe	Tamut Ywa	1	2,100	2,100
Location 9	Hmaw Wun	Pan-taw thaung and Thaung Gyi	13	1,600	20,800
Total			46		92,340

12.3.3 Stakeholders in Sediment Mining

There are three distinct groups of stakeholders in sediment mining, along the supply chain from production to transportation and storage to end-users. In the upstream components, DWIR and GAD are the two relevant government agencies that handle two separate functions, respectively: 1) determining appropriate sites for aggregate mining; and 2) overseeing tender and license issuance procedures. DWIR also designated appropriate transport routes to those contractors who needed permits from the Department of Inland Water Transport and the Yangon Port Authority. The YCDC, Yangon Port Authority, and Department of Human Settlement and Housing Development under the Ministry of Construction have jurisdiction to allocate vacant plots around the Yangon Region for rental to sand and gravel producers who store their aggregates and sort them according to industrial classifications.

Various private parties, from mining contractors to housing material suppliers and construction companies, shape the supply and demand of river aggregates. Although both DWIR and GAD restrict the maximum amount of extraction and excavation of river mining, many licensed and unlicensed contractors mine illegally due to lax regulation and monitoring activities of the GAD. Only in recent months, following heavy public criticisms, have relevant authorities began to regularly inspect mining sites.[76]

Figure 204 - Female labourers carrying sand extracts

In various segments of the value chain, production and transport activities require substantial amounts of day labourers; therefore, employment generation along the value chain is also significant. Day labourers receive wages from 4,300 to 5,000 kyats per day even in the downtime period of 2016 - 20% above the national minimum wage. The mining activities are labour intensive, providing seasonal employment opportunities to rural women, which constitute main work force involved in carrying river aggregates (Figure 202).

Table 133 - Stakeholders in sediment mining

Production	Storage and transportation	Utilization
Licensing Authority: DWIR - determination of sites GAD - issuance of license	Transport Authority: Yangon Port Authority Inland Water transport	Housing material suppliers Construction companies - small, medium

[76] Tachileik News Agency. 'Sediment mining activities were inspected for the first time in 30 years,' 9 May 2017.

Production	Storage and transportation	Utilization
Producers: Licensed sediment mining companies Labour: Day labourers	Rental Plots: Privately run government land plots under the control of YCDC, Department of Human Settlement and Housing Development, Port Authority, Transport as well as private land plots Logistics: Truck companies Shipping companies SMEs in construction industry	Concrete company Large scale construction company Public Works Department, Ministry of Construction

12.3.4 *Regulations and Law Enforcement: Tentative Recommendations*

Under the Law of River System Maintenance, DWIR implemented its due authority prescribed in Clause 36 (b) to establish a five-point regulation for all contractors engaging in river mining activities. The rules stipulated 15-point, detailed rules for the contractors to adhere to when conducting extraction activities. The rules involve not only the DWIR's prerogatives in determination of the sites and volumes for extraction, regular monitoring, and pre- and post-extraction inspections, but also specific conditions that the contractors must follow in respect to navigational, waste management, and reconstructive obligations. Although the regulations warned that violation of the rules may be subject to penalties, the original law stipulated an outdated level of fines that did not serve any material disincentives for willful violations on part of the contractors. More importantly, DWIR does not collect fees directly from the contractors except under the conditions that additional inspections are required in case of violations referred from the relevant GAD office, who enforce the tender process for the extraction sites. In this regard, DWIR lacks both revenue and incentive to conduct regular inspections, and is further limited by budget constraints.

While DWIR's regulations provide technical conditions for the contractors to follow, the actual work licenses must be submitted to the GAD office at the district level where DWIR designated extractive sites. The GAD office then sets the fees to be levied from the contractors and specific guidelines through the Committee on Supervising River Mining Activities, comprised of local officials from relevant ministries such as the ministries of transport and agriculture. Within the committee, the district head of the GAD office is usually chair, and GAD officials execute the tender process for the contractors. Each GAD office may issue district-specific rules that can provide more detailed guidance on the extractive activities; however, some rules may potentially contradict the original intent of the DWIR's regulations. For instance, recent rules issued by one district in Bago Region stipulated detailed provisions such as that each contractor cannot utilize more than five boats for extraction, operated at a minimum of 300 feet away from the riverbank to avoid erosion. However, the rule also contained a provision that once the contractors reach the maximum allowable level of extraction, they can reapply for the license to continue (supposedly beyond the technically specified level set by the DWIR). Such provisions not only encourage over-extraction, but also undermine the authority of the DWIR in specifying the maximum yield of extraction.

In conclusion, the weakness of both legal and institutional controls over sediment mining unintentionally contributes to illegal mining activities, as stated by local communities and NGOs. Through interviews and feedback from the contractors and other key stakeholders, the following areas of governance should be strengthened:

- Systematic and transparent application procedures must be adopted, rather than postponing tenders that unnecessarily distorts the market and encourages illegal mining;
- River policing and official cross-checking must be conducted;
- Law enforcement must act against cartels that monopolize supply chains;
- Awareness of regulatory provisions, legal procedures, penalties to key stakeholders, and affected communities must be promoted; and
- Levies and penalties must be revised in accordance with the market price of the aggregates.

12.4 Teak Certification

Since the 1990s, there has been severe loss of forest area within Myanmar. Degradation of forest cover is also associated with changes in the pattern of run-off in the Ayeyarwady River and its tributaries. As losses of forest cover accelerate water discharge, increase flood risk during the rainy season, and may reduce river flow, Myanmar experiences increased risks of floods along the Ayeyarwady River, particularly during the rainy season. The rainy season of 2015 proved to be one of serious floods and landslides across Myanmar, which resulted in damages and losses to an estimated cost of nearly US$ 2 billion. The magnitude of the disaster raised public awareness of the apparent link between deforestation and flood risks in the country. Even before such awareness, the government has been paying serious attention to addressing the challenges of deforestation in the country, and a number of initiatives have been taken to adopt stricter certification procedures to maintain forest production in a sustainable way. This case study summarizes challenges to ameliorate deforestation and the government's efforts to adapt forest management systems under changing trends of demography and markets, and the progress to adopt new certification procedures in alignment with international standards.

12.4.1 Initiatives on Forest Certification

Concerned with the magnitude of deforestation and illegal logging, successive governments of Myanmar have attempted to align certification initiatives with domestic administrative practices. The first attempt to introduce certification came with a ministerial decree in 1998, which resulted in the formation of the Timber Certification Committee of Myanmar (TCCM) consisting of senior officials of various departments under MOECAF, representatives of the Myanmar Timber Merchant's Association, and a representative from a specialized forestry NGO called the Forest Resource Environment Development and Conservation Association, to develop the guidelines for a certification process. The TCCM was further empowered in 2005 to become a core program of the greater Myanmar Timber Certification Program, which designated 38 out of the total 63 forest districts to develop their own forest management plans, instead of following the national criteria such as AAC. Although the Government of Myanmar did not institute an independent third party assessment at that time, there was an internal review to check the compliance of local controls with designated criteria and indicators including national codes, and requirements for reduced impact logging and chain of custody.

Figure 205 - Illicit teak trade across China-Myanmar border

Large scale cargo fleets of illegal teak trade, involving 800 Chinese nationals, seized by the armed forces of Myanmar in Kachin State in February 2015

Internationally, the TCCM also established links with regional timber certification mechanisms such as the Malaysian Timber Certification Council and the Eco-labeling Institute of Indonesia, concurrent with an attempt to understand international standards and how domestic institutions adopt them. Myanmar has also regularly participated at the Pan-ASEAN Timber Certification Initiative since 2002. The TCCM also developed a new timber certification standard and process, reflective of Myanmar's particular forest management system while using the earlier National Code of Harvesting Practices based on the regional FAO/Asia-Pacific Forestry Commission Code of Practice for Forest Harvesting in Asia-Pacific in 2003. This was done with support from the FAO and the Japanese government, as well as reduced impact logging guidelines adopted in 2008. Despite all of these initiatives, Myanmar has not been able to certify any forests or plantations, as the country has contradicting laws and regulations between different classifications of land including forest lands.[77]

In narrowing these gaps toward sustainable forest management, the Government of Myanmar formed the Myanmar Forest Certification Committee in 2012 to promote awareness and understanding of forest certification process among all levels of stakeholders before implementation of certification. It also sought cooperation with the Programme for the Endorsement of Forest Certification Schemes in 2014, in order to organize stakeholders to build consensus on sustainable forest management requirements and finalize robust standards that contribute to sustainable forest management within the country. With support from the Prince Albert II of Monaco Foundation, the project supported MFCC to establish a multi-stakeholder platform to facilitate better coordination and exchange among forest sector actors. Recently, the Programme for the Endorsement of Forest Certification Schemes and MONREC launched a new pilot project to develop 'test tools that support legal, sustainable and transparent forest product trade' toward sustainable forest management.[78]

At the community level, the Government of Myanmar has been encouraging the harvesting of community forests, though the current schemes do not include the replenishment of teak forests or certification procedures. Nevertheless, the Government of Myanmar established forest user groups (FUG) with legal community forestry certificates, managing more than 40,000 ha of forest (representing only 0.13% of the country's forest cover) and the number of these groups reached 250 by 2011. The rate of establishing FUGs was far behind the government's Master Plan 30-year target of over 900,000 ha by 2030. However, many FUGs are showing dynamic performance and are coming to the fore with innovating results such as the formation of settlement-level subgroups and linkages in attempt to strengthen tenure security in Kachin State. Some FUGs are initiating processes and group formation in the Ayeyarwady Region.[79]

12.4.2 Initiatives on FLEGT

In light of legal and regulatory gaps, the Government of Myanmar sought international cooperation to streamline the country's governance of forest systems in 2013. It initiated a working relationship with the EU to implement the FLEGT program in November 2013 and entered the preparation phase for a VPA after the EU reciprocated in March 2014. As part of the partnership, the Government of Myanmar made a commitment to improve the country's timber legality assurance system and guided Myanmar Forest Certification Committee (MFCC) to commission a gap analysis to identify weaknesses in the current certification system in the context of internationally recognized principles, requirements, and best practices. In February 2017, the MFCC finalized the Myanmar Timber Legality Assurance System (MTLAS) and also held a consultative workshop with 150 national and international stakeholders in Yangon. The report made the following recommendations:[80]

- All possible sources of timber need to be covered, widening the MTLAS's current scope;
- Legality requirements at the forest level need to be better defined;
- Internal checks and external third party verification at the forest level and along the supply chain need to be strengthened;
- Measures to increase transparency and address unethical conduct need to be defined and implemented;
- Mechanisms for overall MTLAS monitoring and oversight need to be incorporated into the system; and
- MTLAS systems, processes, procedures, and data need to be documented and made publically available.

[77] Tin Tin Myint and Norihiko Shiraishi, 'Myanmar endeavor towards forest certification,' Tokyo University Memograph, 2009.
[78] See https://www.pefc.org/news-a-media/general-sfm-news/2375-strengthening-sustainable-forest-management-in-myanmar last accessed on 1 October 2017.
[79] Oliver Springate-Baginski and Maung Than. 'Community Forestry in Myanmar: Some field realities,' August 2011.
[80] FAO. 'Myanmar commits to address gaps in timber legality assurance system for improved forest governance,' www.fao.org; 12 June 2017.

As a tentative step toward legalizing timber export for shipment-based licensing, the Government of Myanmar restricted legal export of timber through Yangon's port. However, much of the timber harvested in border areas still continues to be smuggled, particularly at the China-Myanmar border. Timber shipped through Yangon's port is also challenging to track along the supply chain from harvesting to the point of export. Moreover, problems with forged certificates of origin remain unabated. In many cases, both the exporters of the Myanmar Forest Products Merchant's Federation and the foreign importers particularly from EU and North America were rather slow to demonstrate that the necessary risk assessment and mitigation measures against illegal logging have been strictly followed.

Figure 206 - FLEGT booklet in Myanmar

Figure 207 - Log inspection by FD officer

(ETTF 2017)

The wake-up call for stakeholders in the Myanmar timber trade came in November 2016 when a Swedish Administrative Court ruled that the Myanmar Forest Products Merchant's Federation certificate failed to provide adequate proof that a shipment of teak imported into Sweden had been legally harvested. The court's verdict was made following the investigation of Swedish authorities of the Almtra Nordic for the alleged violation of European Union Timber Regulation (EUTR), which resulted in a fine of 17,000 Swedish kronor (US$ 1,700). However, a more damaging impact to Myanmar was the Swedish EUTR regulator's decision not to source wood from Myanmar under current circumstances.

In response to the Swedish court situation, the Government of Myanmar identified what went wrong along the supply chain and issued the following statement in March 2017 (Ecosystem Marketplace 2017):

'We acknowledge, however, that the system may be complex for external parties to navigate. We are also aware that some EU importers are facing challenges in accessing documentation needed to demonstrate the chain of custody of their purchases back to specific forest areas when exercising due diligence as required by the EUTR. We also acknowledge that mixing of logs from multiple sources at various points in supply chains may complicate tracing of timber supplies in exported products.

In this regard, MONREC is committed to streamlining our systems, including simplification of current hammer-marking, so that our exporters can clearly demonstrate to their customers that all our timber product exports comply with our laws. This commitment was reiterated during a meeting with international timber traders' federations held in Yangon on 18 February 2017.' (MONREC 2017)

Figure 208 - Chief Minister of Ayeyarwady speaking at regional FLEGT VPA meeting

(GAD, Ayeyarwady Region Government)

In accordance with the new guidelines, the FD also formed a joint focal group to prepare a dossier to assist stakeholders with clarity of traceability system in Myanmar. The FD also reduced the annual allowable timber cut to half of the previous levels in 2017/2018 in order to aid traceability. Meanwhile, it also pledged to implement the MATLAS and other work plans to achieve the benchmarks required by the VPA of the FLEGT program. In fact, the MONREC has already taken concrete steps in mobilizing grassroots participation in FLEGT processes as it facilitated the formation of sub-national FLEGT multi-stakeholder groups across the country to promote participatory process in volunteer partnership agreement. At the time of analysis, as many as 10 sub-national governments have already convened FLEGT ministerial steering group meetings and initiated the formation of working groups - a concrete step toward building the foundation for sustainable forest governance.

12.4.3 Conclusion

Myanmar's consistent movement toward reform lays the foundation for future access to high margin markets in the EU and the USA. Recently, the US-based International Wood Products Association made trade exchanges with Myanmar authorities and traders to facilitate direct trade import of non-sanctioned forest products. With increasing integration with international legal assurance systems, the Government of Myanmar is highly committed to accelerate the country's forestry reform while seeking greater support of the domestic wood-processing industries to add more value for export - a long-term strategy to mitigate over-exploitation of forest resources as well as to ensure sustainable development goals for all stakeholders. Such reforms will not only speed up the international recognition of Myanmar's forest certification system, but also help restore its renown as the origin of last remaining teak forests in the world.

13 CONCLUSION

When considering the Ayeyarwady Basin, the feature that is most likely noted is the extent of its area, and the sheer variety of ecosystems, populations, sociocultural practices, and economic activities it supports. The Ayeyarwady itself is 2,170 km long, while the Ayeyarwady Basin covers approximately 376,500 km^2 (61%) of Myanmar's land area and is home to approximately 64% of the national population. As the report has shown, the basin hosts a wide variety of economic activities and socioeconomic conditions. Given such an extensive scope, this report aims to offer a characterization of the basin in general terms.

Nevertheless, SOBA 5 has sought to establish a comprehensive baseline for all major socioeconomic sectors in the Ayeyarwady Basin, based largely upon secondary data supplemented where possible by stakeholder consultation and peer reviews of findings. Key challenges included the lack of comprehensive datasets for the Ayeyarwady Basin, inconsistent and poor-quality data, and the lack of sufficient granularity to allow the accurate mapping of geospatial data. Nevertheless, through the use of available quantitative data supported with qualitative accounts of important causal processes in the basin and, where possible, stakeholder consultations, we have attempted to construct a convincing narrative. The report thus seeks to piece together disparate, partial, and often contradictory information to form a coherent narrative on the development trends and issues in the Ayeyarwady Basin.

Specific conclusions and recommendations are included in each chapter and we do not seek to repeat them here. Rather the focus of this final section is the development of a more general characterization of trends in the Ayeyarwady Basin, the identification of associated key issues for development and river basin planning in the Ayeyarwady Basin, and brief recommendations related to the development of a river basin plan (as opposed to specific sector recommendations).

Broadly speaking, there are three main interrelated but geographically discrete trends which currently characterize development processes in the basin, 1) those of the 'frontier' upland areas based around the extraction and development of natural resources (notably timber and mining); 2) those of the urban entrepots centred around services and increasingly manufacturing; and 3) those of the rural heartlands in the dry zone and Ayeyarwady Delta. We consider each of these in turn.

13.1 Natural Resource Development at the Frontier

Despite recent growth in the manufacturing and service sectors, natural resource development and the extractive industries of forestry, mining, and energy development in particular remain an important part of the national economy. Given the substantial share of these natural resources in illegal trade, their impact is much larger than is recognized in economic figures. These extractive activities are predominately located in the upland areas of the Ayeyarwady Basin in Shan State, Kachin State, and Sagaing Region. The most obvious example of this is perhaps in the unchecked mining activities in Hpakant, Mogok, and in the gold mines and placer deposits scattered throughout the Upper Ayeyarwady, Chindwin, and Middle Ayeyarwady HEZs. Most of the high value jade and precious stones is illegal and goes unrecorded and untaxed.

These upland areas also contain the bulk of the country's intact high conservation vlaue forests; as the remaining high-value timber attracts logging activities, much of this is also effectively illegal and linked to the border trade. The development of plantations and agro-forestry concessions has also been implicated in the de-gazetting of forests to allow logging. The commercialization of agriculture both through the development of concessions and through contract farming to serve Chinese markets has also been an important trend in Kachin and Shan states.

These upland areas also have the best HP potential and have attracted the attention of developers. China's ever-increasing demand for power and investment opportunities, together with the development of large loads in the region serving new mining investments and growing domestic demand, have led since the early 2000s to something of a HP development boom. The failure of expected demand growth to materialize in China and investor concerns over Myitsone may stall proposed investments in the short term, but the structural dynamics driving these projects are unlikely to change.

These rapid changes are causing significant social change. Most of the indigenous population in these areas remains excluded from the wider economic growth the country is enjoying and still suffer from high levels of poverty and poor services. Frontier towns like Myitkiniya, Mogok, and Hpakant, and towns on the border with the PRC have grown rapidly, with large transient populations who have moved from elsewhere in the country in search of economic opportunities. These communities composed predominantly of single male in-migrants face particular problems with crime, drug abuse, and disease.

Natural resource and infrastructure development have also brought with them significant environmental degradation. Deforestation and unchecked mining activities have caused land degradation and erosion. Large populations moving into these remote areas have resulted in the over exploitation of NTFPs and use of fuelwood. Deforestation and mining have caused significant environmental damage in some locations such as in the Uyu River Basin. Mining has also been implicated in increasing concerns related to mercury emissions in the river basin.

Contributing factors to the growing dynamism in these regions have been the rapid growth and development of China, the proximity to which has driven much of the development. Hydropower, agroforestry and contract farming, timber, and mining are all driven by Chinese demand or Chinese investment. If China has been the main structural driver of these development trends, the relative absence of civil conflict in Kachin and northern Shan states which the area enjoyed up until relatively recently, was the main enabling factor for much of this development to take place. At the same time the unchecked exploitation of natural resources in these regions has been an important factor in the resurgence of civil conflict in some of these areas.

13.2 Urbanization and Export-led Manufacturing

The second major geographical development trend in the Ayeyarwady Basin is the urbanization and secondary sector development. This is perhaps less well established than the trends in direct natural resource exploitation, but is at an inflection point and on the cusp of rapid acceleration. In many ways, development of urban areas represents the future for Myanmar and the Ayeyarwady Basin, as urban areas are seeing rapid expansion. Expansion is taking place in terms of population, physical area, infrastructure, and construction development, but also in terms of production and investment in these areas. This trend is concentrated around the large urban centres of the Ayeyarwady Basin - mainly Yangon, but also Mandalay, and to a lesser extent secondary urban centres such as Pathein. High population growth rates in urban areas are explained largely by rural-urban migration from adjacent rural regions and states (Ayeyarwady region, Bago region, and Magwe region in the case of Yangon, and Sagaing region in the case of Mandalay). Migrants are generally attracted by the economic opportunities offered by wage employment in manufacturing, construction, and services in these urban areas.

The growth in opportunities in urban areas has been largely a consequence of economic reforms starting in the 1990s, coupled with the global boom in natural resource sectors. This enabled and encouraged investment in real estate and the manufacturing sector largely in and around urban areas. Investment has grown and the rate of investment has accelerated with continuing political and economic reforms. Since 2011, the election of the new government, the liberalization of the exchange rate and the drafting of a law on foreign investment have seen the rapid expansion of foreign investment concentrated in the manufacturing sector. The development of IZs and SEZs has further facilitated these developments. It is the stated objective of government to promote such investments, concentrating initially on manufacturing in the food and beverage, and garments and textile sectors. The government thus hopes to follow the path of other rapidly developing countries in the region though the development of export-led manufacturing industry.

Such rapid and highly concentrated growth in the major urban areas is attracting people and resources from the broader river basin. Population growth is slowing in adjacent rural areas and is expected to turn negative in the coming decades. Water demand for municipal use is expected to increase dramatically, as are abstractions for manufacturing (particularly as garment, textiles, and food and beverage sectors are typically water intensive), although of greater concern is the large growth in water pollution emissions from municipal waste water and pollution emissions from the manufacturing sector.

At the same time, urban energy requirements are growing dramatically. This will imply not only greater reliance on energy imports, but also greater demand for energy sources from the rest of the basin: in particular, greater demand, at least in the short term for fuelwood charcoal, and in the long term for electricity. Fuelwood and charcoal demands will likely be met through reliance on unsustainable harvesting at increasing distances from the urban centre as local resources are denuded. Growing electricity demands are expected to be met initially though improvements and upgrading of the current supply and generation system, but in the medium to long term, these urban demands will likely also require the development of HP in the upper reaches of the Ayeyarwady Basin. The demand of building materials such as cement and aggregates is leading to huge increases in aggregate mining and limestone in the basin, with knock-on implications for geomorphological processes, such as increased river bank erosion. Moreover, increased demand for transport between urban centres for freight and passengers will require the development of greater transport capacity by road, rail, or navigation - and probably some combination of the three. At the same time, these urban areas, their populations, and infrastructure complexes will be vulnerable to floods and other climatic impacts.

13.3 Stagnation in the Agricultural Heartlands

The third geographical trend in the basin is that of the development in the predominantly lowlands of the Ayeyarwady Basin floodplains, including the dry zone and the delta. Rather than the dynamic change experienced in the urban centre and upland periphery, the rural heartlands of the basin are rather characterized by a lack of change, or stagnation. This is most obviously indicated by the stagnation in agricultural output, and the observation that a large part of agricultural sector growth has come from the expansion of cropped land, rather than higher productivity in existing agricultural areas. The use of inputs remains low. While some large irrigation schemes have been invested in, reports suggest that only a fraction of this is functional or actually used. Mechanization, the use of improved seed, livestock breeds, and chemical inputs is low.

The lack of dynamism and change in these predominantly agricultural areas can be explained in part by the lack of investment in support infrastructure (transport, electricity, irrigation, etc.), the lack of government support for agricultural extension activities, the flood prone nature of much of the area, and restrictive regulations for cropping and the marketing of crops in the past. Weak land tenure and land administration is also likely to stymy small holder investment in agriculture, taking away the incentive to improve agricultural land and restricting the potential collateralization of rights to land.

13.4 Interconnections Between Geographical Development Trends

These three geographical trends are of course interrelated. Rural poverty and stagnation of the agricultural economy in the more populous rural areas of the lowlands, floodplains, and deltas is an important push-factor influencing the decision to migrate, be it to urban areas in search of work in the manufacturing and construction sectors, or other rural areas to work in the mining sector around Mandalay region, Mogok, Hpkant, or elsewhere. The substantial financial resources generated by the trade in timber and precious stones is likely a key factor driving real estate development in Yangon and elsewhere. Much of the inland waterway traffic depends upon bulk cargoes such as timber and coal from the natural resource sectors. Sand mining for the construction sector also constitutes an important part of navigation traffic. Hydropower development in the upland river basin serves urban load centres as well as mines. Agricultural outputs provide inputs to the food and beverage manufacturing sector.

Development of the natural resource wealth in the north of the basin has been responsive to Chinese influence in terms of direct investment and as the main market for natural resources produced there, and production in the large urban agglomerations has grown in response to international trade and investment. The development of the central agricultural regions of the basin, by contrast has not attracted much investment from government or the private sector. Despite its importance for poverty reduction, in terms of export potential and provision of inputs to other sectors, and its obvious sociocultural importance, it is difficult to get away from the impression that the sector has not received the attention it deserves.

ANNEX I - AYEYARWADY BASIN EXPORT ESTIMATES

Table 134 - Myanmar's exports by major commodity group and estimates of Ayeyarwady Basin contribution, 2014

(CSO data and consultants' estimates)

Commodity group	National exports		Ayeyarwady Basin exports			Basis for estimate
	Value (million US$)	Share of total (%)	Value (million US$)	Share of national (%)	Share of Ayeyarwady Basin (%)	
Miscellaneous manufactured articles	5,227	41.74	3,805	72.8	60.76	Estimated manufacturing production
Mineral products	3,859	30.82	-	-	-	Exports are almost entirely composed of gas exports from off-shore production located outside the Ayeyarwady Basin
Vegetable products	1,197	9.56	706	59.0	11.28	Estimated share of national agricultural production
Textiles and textile articles	1,046	8.36	785	75.0	12.53	Share of manufacturing enterprises and garment sector employment in the Ayeyarwady Basin
Base metals and articles of base metal	397	3.17	357	90.0	5.71	Share of minerals production in the Ayeyarwady Basin
Precious, semi-precious stones, precious metals	280	2.24	280	100.0	4.48	Assumed that practically all this is composed of exports of jade and gems, all sourced from the Ayeyarwady Basin
Live animals, animal products	165	1.31	63	38.1	1.00	Share of livestock production in Ayeyarwady Basin
Wood and articles of wood	88	0.70	77	87.4	1.23	Share of timber production
Footwear	78	0.62	58	75.0	0.93	As with textiles and garments
Plastics, rubber and articles thereof	50	0.40	36	72.8	0.58	Estimated manufacturing production
Transport and transport equipment	30	0.24	22	72.8	0.35	Estimated manufacturing production
Optical/measurement instruments	28	0.23	21	72.8	0.33	Estimated manufacturing production
Machinery and mechanical appliances	26	0.21	19	72.8	0.31	Estimated manufacturing production
Art, antiques	20	0.16	13	64.0	0.21	Share of population

Commodity group	National exports		Ayeyarwady Basin exports			Basis for estimate
	Value (million US$)	Share of total (%)	Value (million US$)	Share of national (%)	Share of Ayeyarwady Basin (%)	
Processed foodstuffs, beverages	14	0.11	10	72.8	0.16	Estimated manufacturing production
Hides, skins, leather, etc.	9	0.07	3	38.1	0.05	Share of livestock production in the Ayeyarwady Basin
Wood pulp, paper	5	0.04	4	72.8	0.06	Estimated manufacturing production
Stone, plaster, asbestos articles	2	0.01	1	72.8	0.02	Estimated manufacturing production
Animal and vegetable fats	1	0.01	1	72.8	0.01	Estimated manufacturing production
Chemicals	1	0.00	1	100.0	0.01	All refineries and petrochemical industries are assumed to be located in the Ayeyarwady Basin
Total	**12,524**	**100.00**	**6,263**	**50.0**	**100**	

ANNEX II - METHODOLOGY FOR DEMOGRAPHIC AND RURAL LIVELIHOODS ANALYSIS

Much of the statistical data for analysis from Census 2014 are at township level. As township boundaries in some cases cut across HEZ (and basin) boundaries, the statistics are based on a GIS operation whereby township centroids, i.e., their geometrical mid-points, have been calculated to convert the area polygons to points, and then overlaid on HEZ polygons. Though this operation solves the problem of crossing boundaries, it does create some error in the statistical calculation of values for the HEZs pertaining to townships located near the HEZ boundaries. This is because the township centroid may not always represent the exact location of the majority of the population in the township. Thus, a township population that actually lives within a particular HEZ may be counted as living in the neighbouring HEZ. However, the error is judged to be small.

With regard to migration, the highest resolution of data is for district level (Thematic Report on Migration and Urbanization, Census Report, Volume 4-D, December 2016). Since districts are large, a number of them cut across several HEZs (Figure 209). Applying the district centroids to place districts within HEZs would create too much error. Instead, district boundaries have been overlaid on HEZ boundaries and districts have been allocated to HEZs on that basis, which means that data from a particular district in some cases is allocated to more than one HEZ. This means that mean percentages of migration flows can be calculated. Summing up the number of persons migrating in or out of a HEZ would imply some cases of double or triple counts. To counter that issue, the number of persons who migrated in or out of HEZs have been divided by the number of HEZs that a particular district overlaps (in Section 2.1.2).

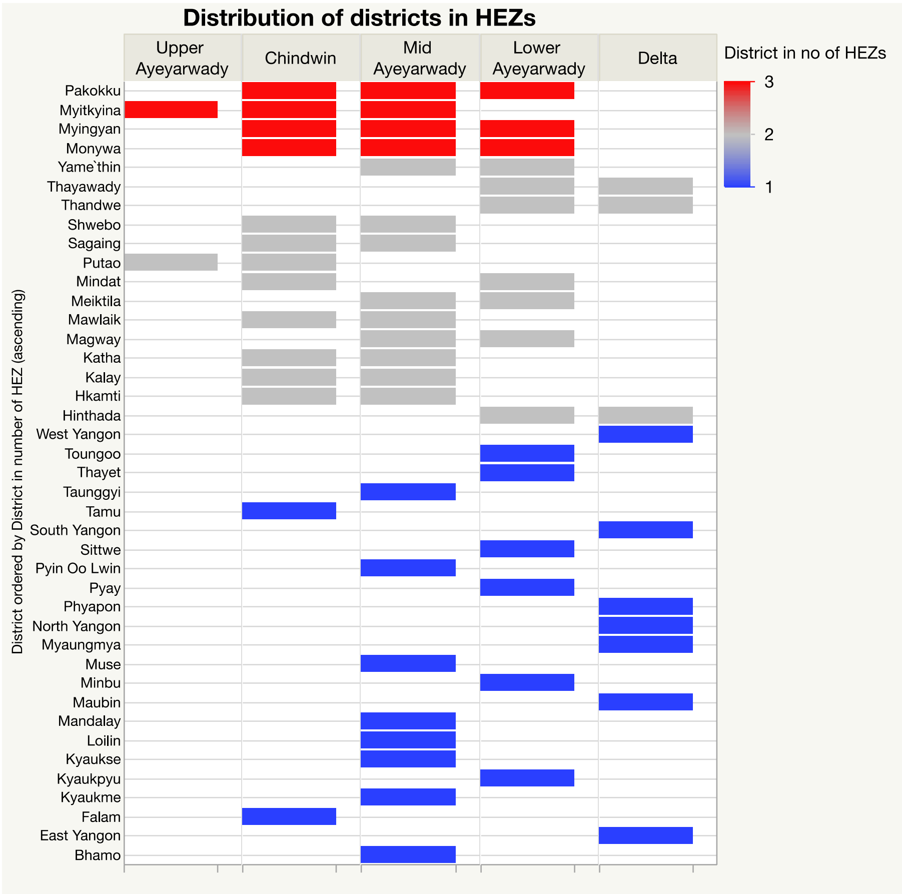


Figure 209 - Number of and distribution of districts in hydro-ecological zones

(MIMU, 2017; SOBA, 2017) GIS analysis: topology overlay of district layer [MIMU] on HEZ layer [SOBA]

Poverty data are only available at State-Region-Divisions level. They are from the IHLCS carried out in 2009/2010. Applying State-Region-Division level data to the Ayeyarwady Basin and HEZs is not statistically sound as the boundaries cuts across both the Ayeyarwady Basin and the HEZs.

Figure 210 shows the Ayeyarwady Basin and HEZs boundaries overlaid on State-Region-Division boundaries. It is immediately clear that the IHLCS and other data, which are valid at State-Region-Division level, cannot be applied to the Ayeyarwady Basin and HEZs.

The analysis of other aspects of social and livelihoods is mainly based on statistical analysis of distributions of township level values presented in Census 2014. For analysis of Ayeyarwady Basin and HEZ level analysis, the mean/averages are presented together with distribution across quantiles to give an impression of the spread within the Ayeyarwady Basin and the HEZs.

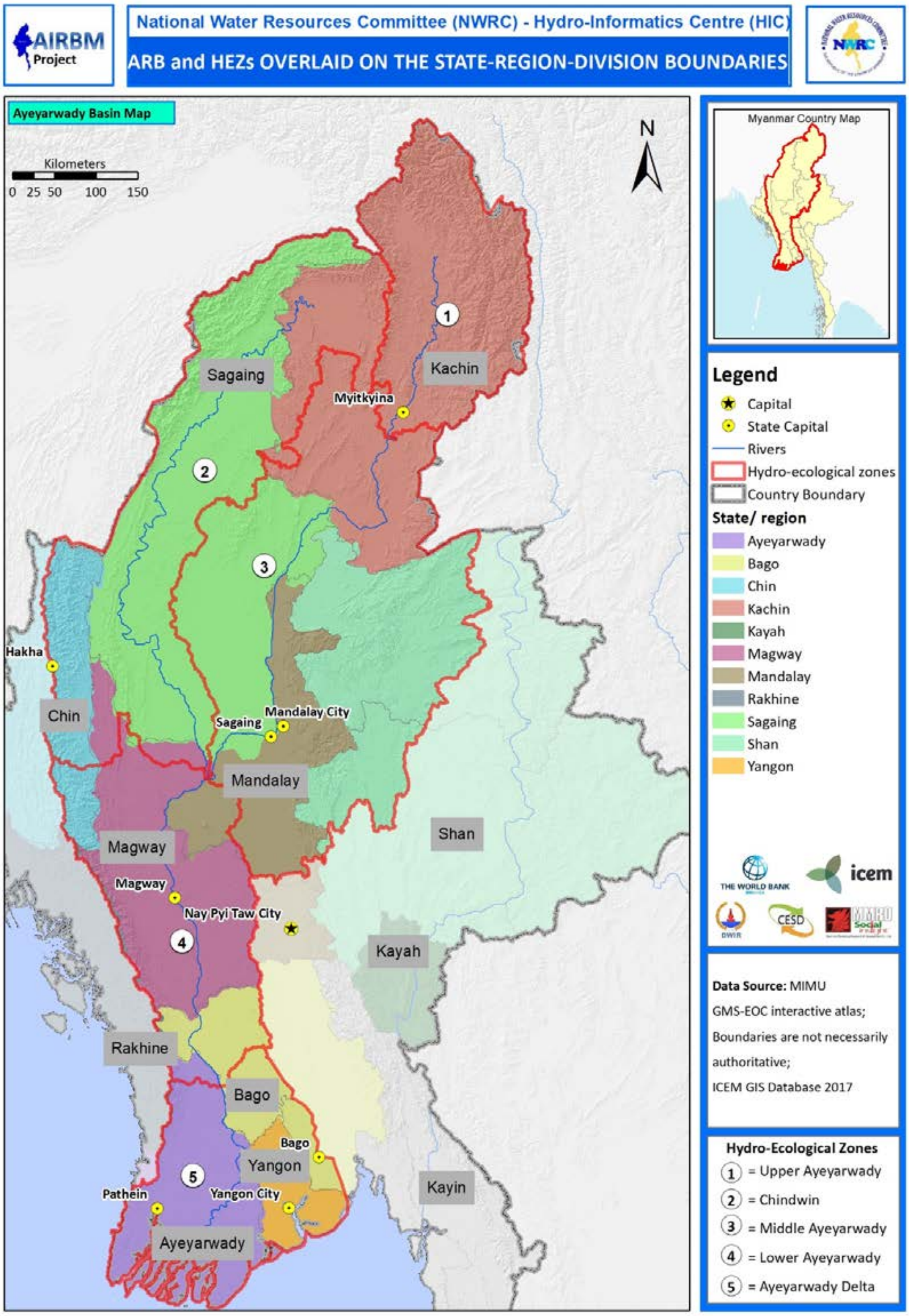


Figure 210 - Ayeyarwady Basin and hydro-ecological zones overlaid on State-Region-Division boundaries

ANNEX III - HARVESTED AREAS

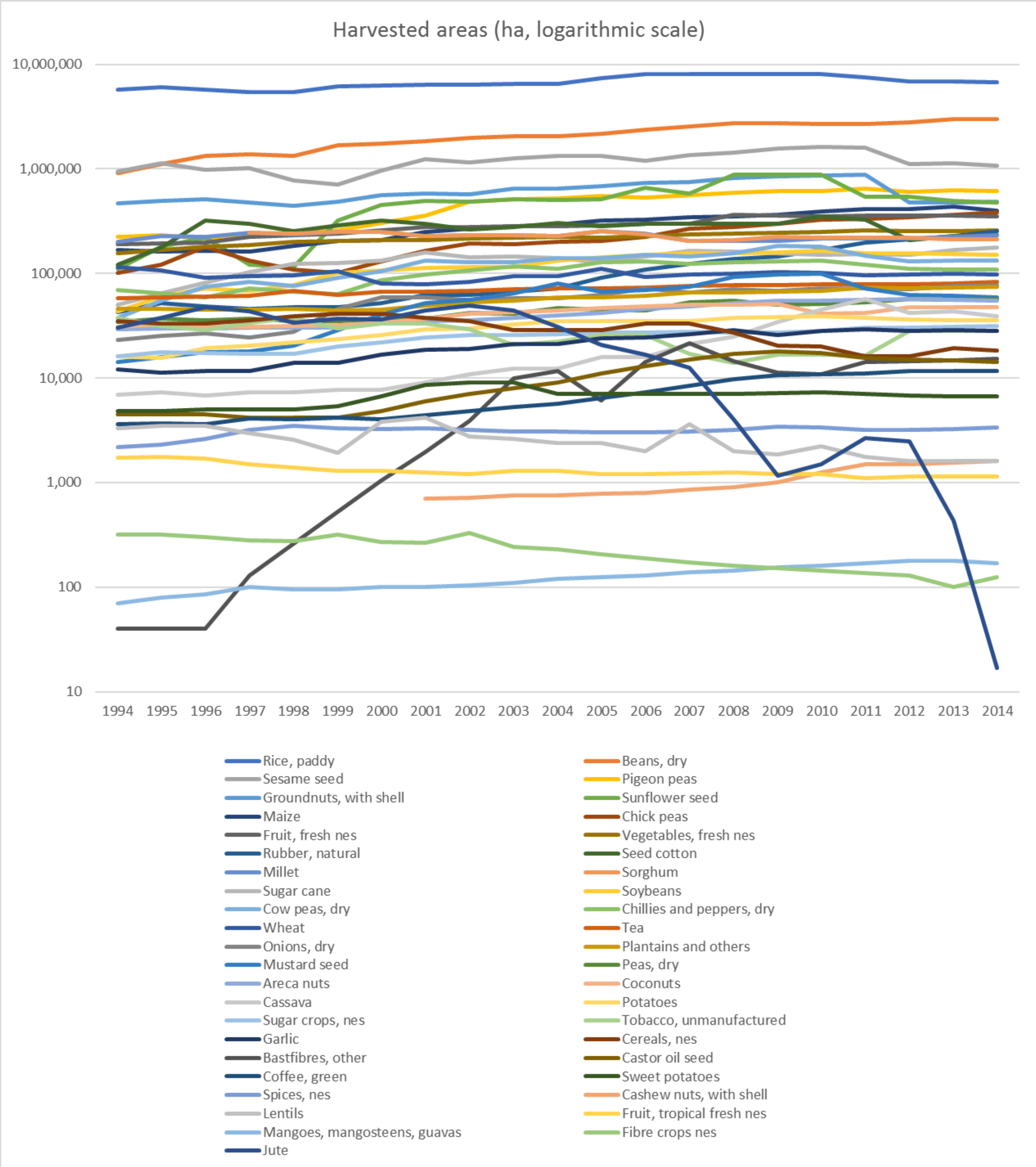


Figure 211 - Harvested areas of crops in Myanmar (ha, logarithmic scale), 1994 - 2014

(FAO 2017b)

ANNEX IV - FOOD BALANCE SHEET

Table 135 - Myanmar Food Balance Sheet 2013

(Compiled and calculated from FAO 2017b) Ordered by energy

Commodity	1,000 tonne									kg/capita/y	kcal/capita/day	g/capita/day	g/capita/day
	Production	Import	Export	Stock	Supply	Feed	Seed	Losses	Food	Food	Energy	Protein	Fat
Rice (milled equivalent)	19,188	21	512	-899	19,596	7,882	556	576	7,073	132.8	1,234	28.87	5.5
Sugar non-centrifugal	787				787				787	14.77	145	0.45	0.12
Pig meat	621				621			19	602	11.31	111	3.44	10.69
Groundnut oil	225				225				225	4.22	102		11.55
Pulses	1,469		54		1,415	496	40	15	544	10.21	97	5.79	0.86
Poultry meat	1,196	1			1,197			33	1,165	21.87	83	7.15	5.82
Milk, excluding butter	1,708	93			1,801			123	1,677	31.48	50	3.91	2.6
Freshwater fish	1,921		8	-1	1,914				1,372	25.77	49	7.71	1.77
Wheat and products	188	206	1		393	37	6	19	331	6.22	47	1.16	0.24
Vegetables, other	3,612	1	4		3,609			351	3,258	61.18	46	2.53	0.35
Marine fish, other	2,110	4	441		1,673	62			1,501	28.19	45	6.44	1.55
Maize and products	1,700	2	77	300	1,325	1,020	14	85	206	3.87	35	0.86	0.32
Groundnuts (shelled eq.)	962		1	-1	962		105	29	124	2.33	35	1.49	2.89
Coconuts, including copra	425				425			13	412	7.74	32	0.32	2.86
Plantains	1,000				1,000			150	850	15.96	31	0.31	0.09
Fruits, other	1,308	16	21	-1	1,304			65	1,239	23.26	30	0.33	0.3
Cassava and products	630	3			633			63	570	10.7	30	0.2	0.09
Bovine meat	262	1			263				263	4.94	26	1.81	2.04
Sesame seed oil	329		1		328				58	1.08	26		2.97
Eggs	425				425		61	21	343	6.45	25	1.9	1.78
Beans	3,700		1,370		2,330	1,900	110	185	135	2.54	24	1.49	0.09
Sunflower seed oil	124				124				50	0.93	23		2.56
Onions	1,141		5		1,136			57	1,079	20.26	21	0.83	0.11
Sesame seed	890		33		857		16		71	1.34	21	0.63	1.93
Cottonseed oil	42				42				42	0.79	19		2.15
Potatoes and products	620				620		26	62	532	9.98	18	0.44	0.03
Pimento	129		3		126			4	122	2.29	18	0.73	0.78
Fats, animals, raw	45	3			48				48	0.89	18	0.1	1.95

Commodity	1,000 tonne									kg/capita/y	kcal/capita/day	g/capita/day	g/capita/day
	Production	Import	Export	Stock	Supply	Feed	Seed	Losses	Food	Food	Energy	Protein	Fat
Soya bean oil	30	5		1	34				34	0.64	16		1.76
Nuts and products	121		4		117			4	116	2.17	15	0.29	0.26
Sorghum and products	215				215	118	8	11	78	1.46	14	0.4	0.13
Sweeteners, other	440	41			481				81	1.52	12		
Butter, ghee	30	1			31				31	0.58	12	0.01	1.31
Palm oil		607			607				15	0.29	7		0.79
Sugar (raw equivalent)	23	158	5	145	31				31	0.58	6		
Offal, edible	82				82				82	1.53	5	0.75	0.14
Beer		158	1		157				157	2.95	4	0.04	
Mutton and goat meat	48				48				48	0.89	4	0.37	0.28
Beverages, alcoholic	20	6			26				26	0.48	4		
Millet and products	185				185	148	4	9	24	0.44	4	0.1	0.03
Soya beans	205		5		200		10	4	21	0.38	4	0.4	0.19
Sweet potatoes	52				52			5	46	0.87	2	0.02	0.01
Sunflower seed	360	2			362		17		18	0.34	2	0.08	0.16
Cereals, other	13	2			15		1	1	13	0.25	2	0.06	0.01
Sugar cane	9,650				9,650		395	483	97	1.81	1		0.01
Coffee and products	8	50			58				58	1.09	1	0.07	
Tea (including mate)	32	2	2		32				32	0.61	1	0.17	
Pelagic fish	13	3	1		15				15	0.29	1	0.09	0.03
Spices, other	6	2	5	1	2				3	0.06	1	0.02	0.02
Oil crops oil, other		15		-1	16				2	0.04	1		0.1
Palm kernel oil		2			2				2	0.03	1		0.08
Crustaceans	100	4	97		7				7	0.13		0.03	
Apples and products		5			5				5	0.09			
Wine		4			4				4	0.07			
Meat, other		1			1				1	0.02		0.01	0.01
Infant food		1			1				1	0.02		0.01	
Honey	2		2							0.01			
Cocoa		1			1				1	0.01			0.02
Demersal fish		1			1				1	0.01		0.01	0.01
Aquatic animals, others	5		5							0.01			
Barley and products		43			43								

Commodity	1,000 tonne									kg/capita/y	kcal/capita/day	g/capita/day	g/capita/day
	Production	Import	Export	Stock	Supply	Feed	Seed	Losses	Food	Food	Energy	Protein	Fat
Rape and mustard seed	91				91		1	1					
Cottonseed	280				280		10	8					
Oil crops, other	12		11		1								
Rape and mustard oil	22				22								
Rice bran oil	29				29								
Alcohol, non-food	1,040				1,040								
Total											2,561	81.82	69.34

Population: 53.295 million

ANNEX V - FOOD SECURITY INDEX MYANMAR

Category	Myanmar			Average score (all countries)
	Score 2017	Change 2016	Rank	
OVERALL	**44.8**	**-0.7**	**80**	**57.3**
1) AFFORDABILITY	34.6	+1.4	84	54.8
1.1) Food consumption as a share of household expenditure	6.2	+6.2	112	58.6
1.2) Proportion of population under global poverty line	68.0	-0.2	74	73.0
1.3) Gross domestic product per capita (US$ PPP)	3.4	+0.2	80	14.5
1.4) Agricultural import tariffs	87.4	0.0	15	76.4
1.5) Presence of food safety net programmes	50.0	0.0	66	65.5
1.6) Access to financing for farmers	25.0	0.0	82	61.3
2) AVAILABILITY	51.1	-2.9	72	59.0
2.1) Sufficiency of supply	31.3	-13.0	=97	56.5
2.2) Public expenditure on agricultural research and development	0.0	0.0	62	15.0
2.3) Agricultural infrastructure	41.7	0.0	=78	57.6
2.4) Volatility of agricultural production	96.3	0.0	16	86.2
2.5) Political stability risk	35.3	-14.7	69	46.8
2.6) Corruption	25.0	+25.0	48	37.4
2.7) Urban absorption capacity	83.4	-9.0	2	66.6
2.8) Food loss	89.2	0.0	56	84.9
3) QUALITY AND SAFETY	53.1	0.0	71	58.7
3.1) Diet diversification	50.0	0.0	68	56.4
3.2) Micronutrient availability	32.4	0.0	82	43.9
3.3) Protein quality	38.2	0.0	73	49.4
3.4) Food safety	71.2	0.0	81	80.5

(Global Food Security Index)

ANNEX VI - MAPS

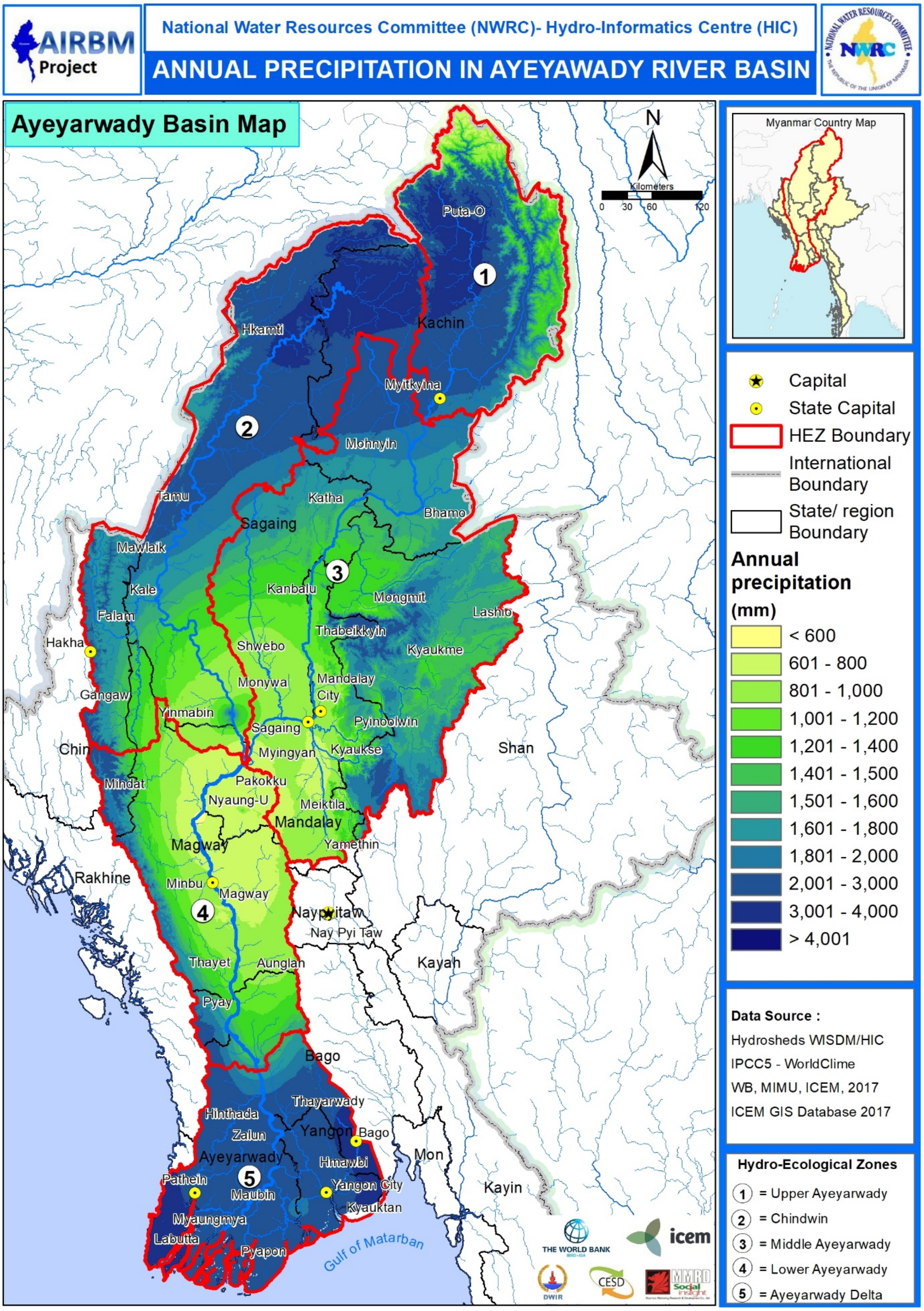


Figure 212 - Annual precipitation in the Ayeyarwady Basin

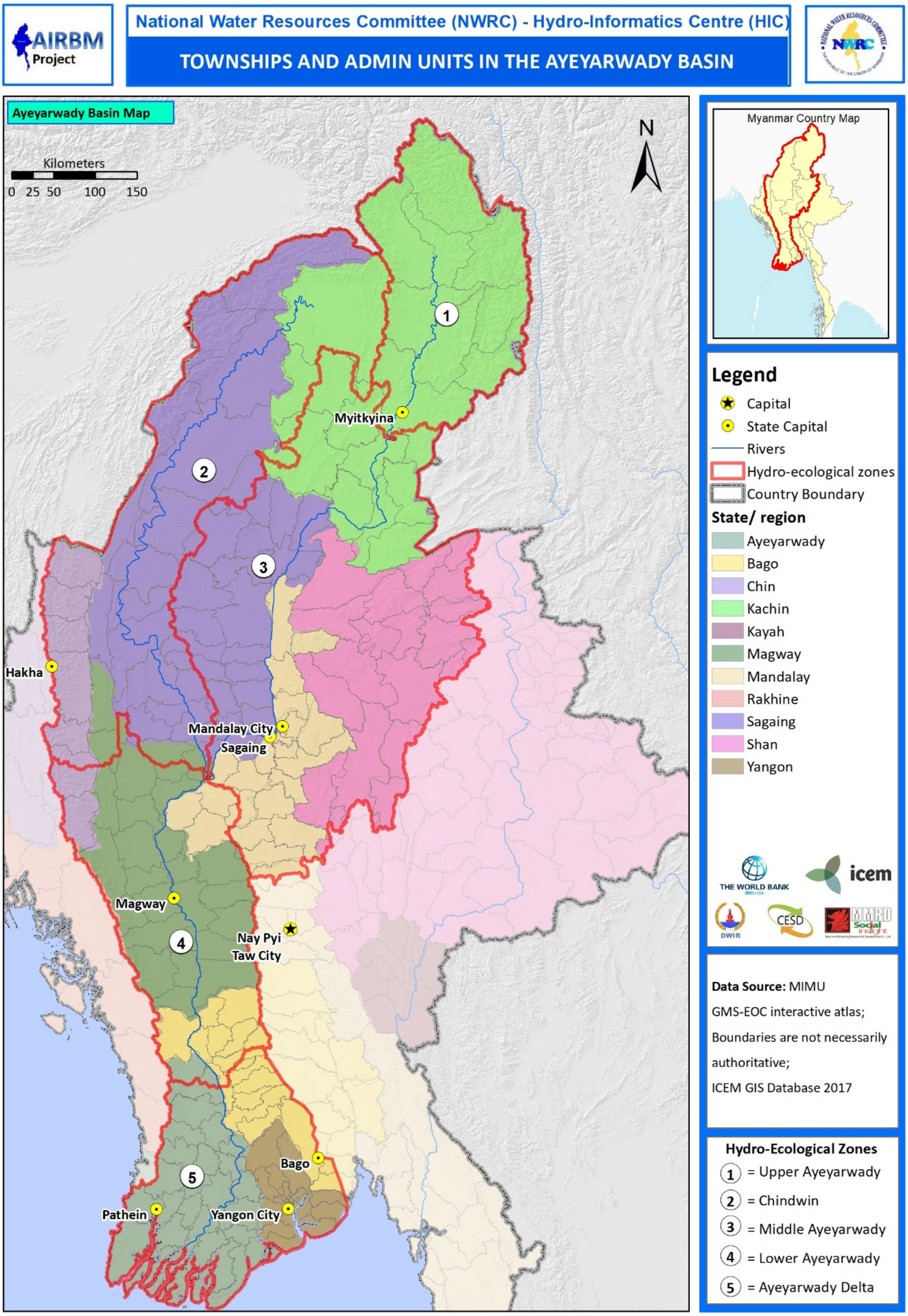


Figure 213 - Hydro-ecological zones of the Ayeyarwady Basin

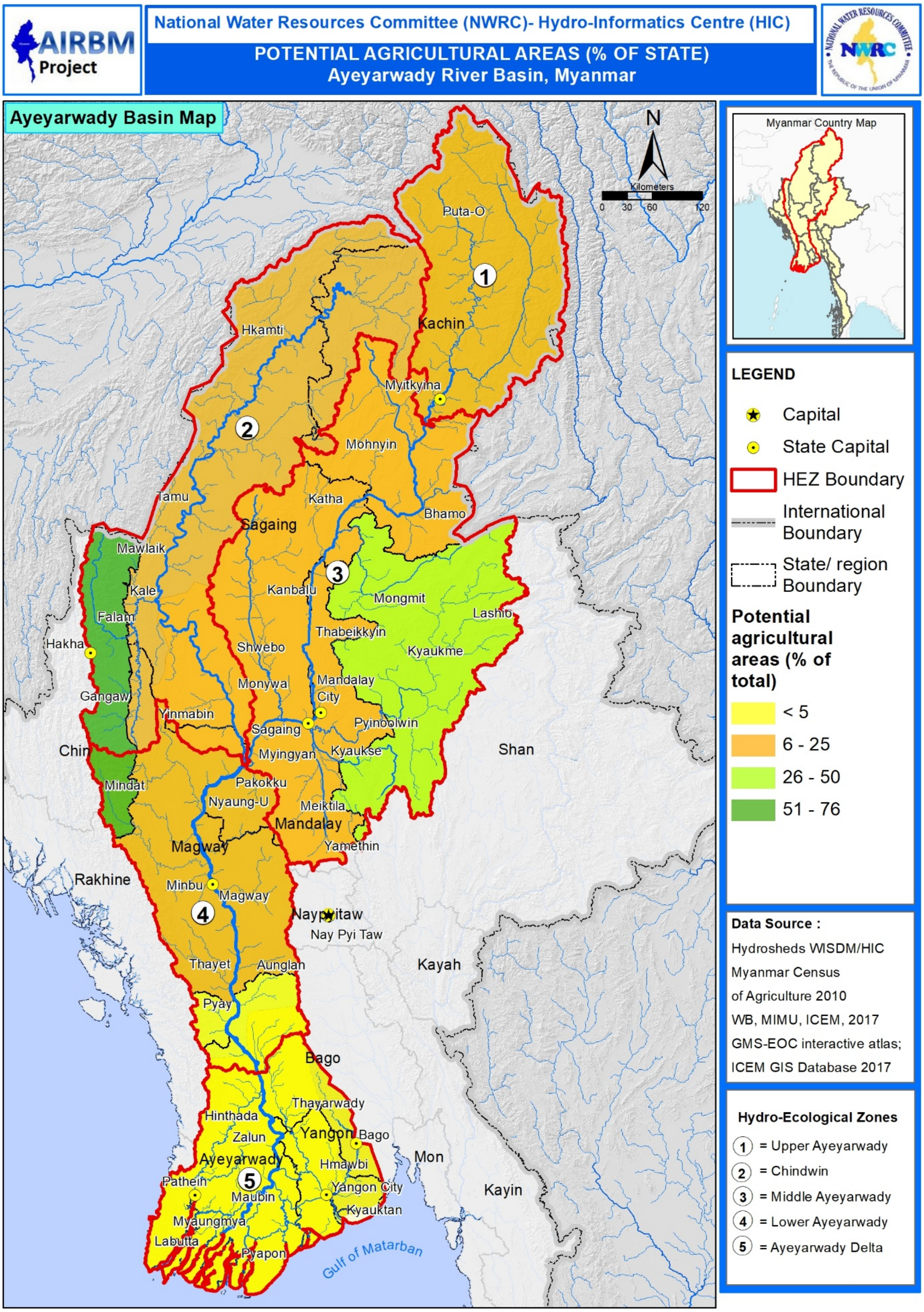


Figure 214 - Potential agricultural land

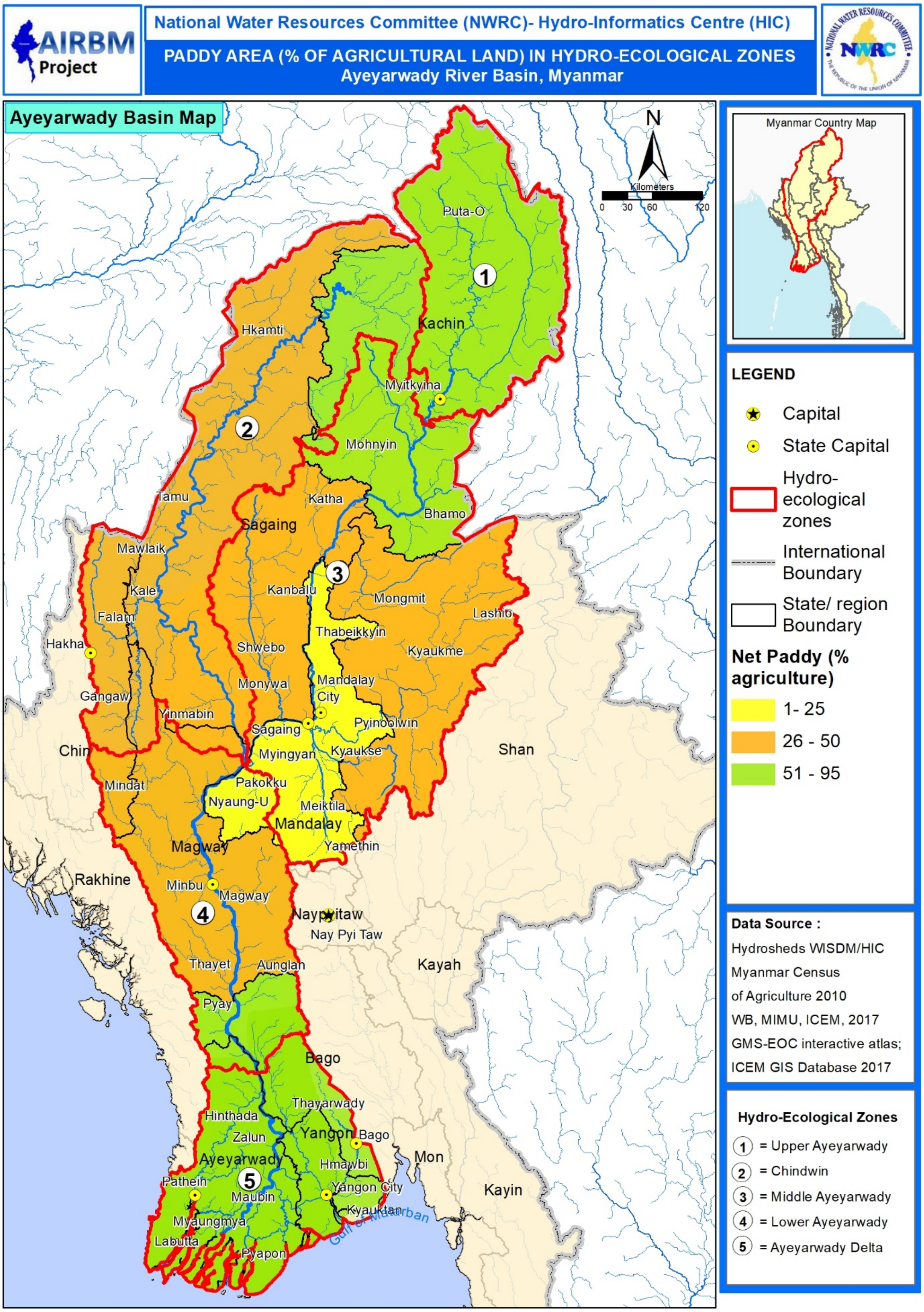


Figure 215 - Paddy area in hydro-ecological zones of the Ayeyarwady Basin

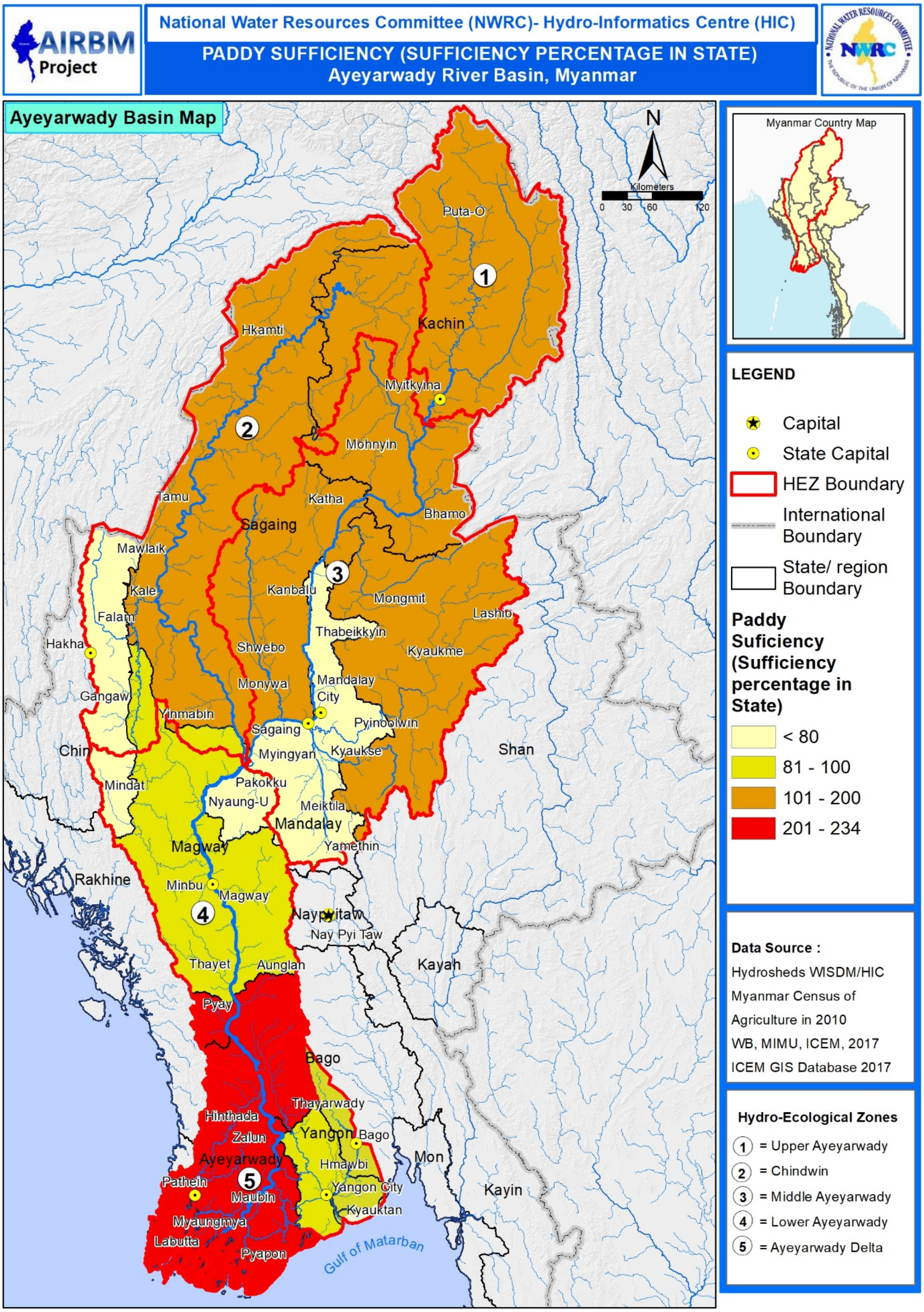


Figure 216 - Paddy sufficiency

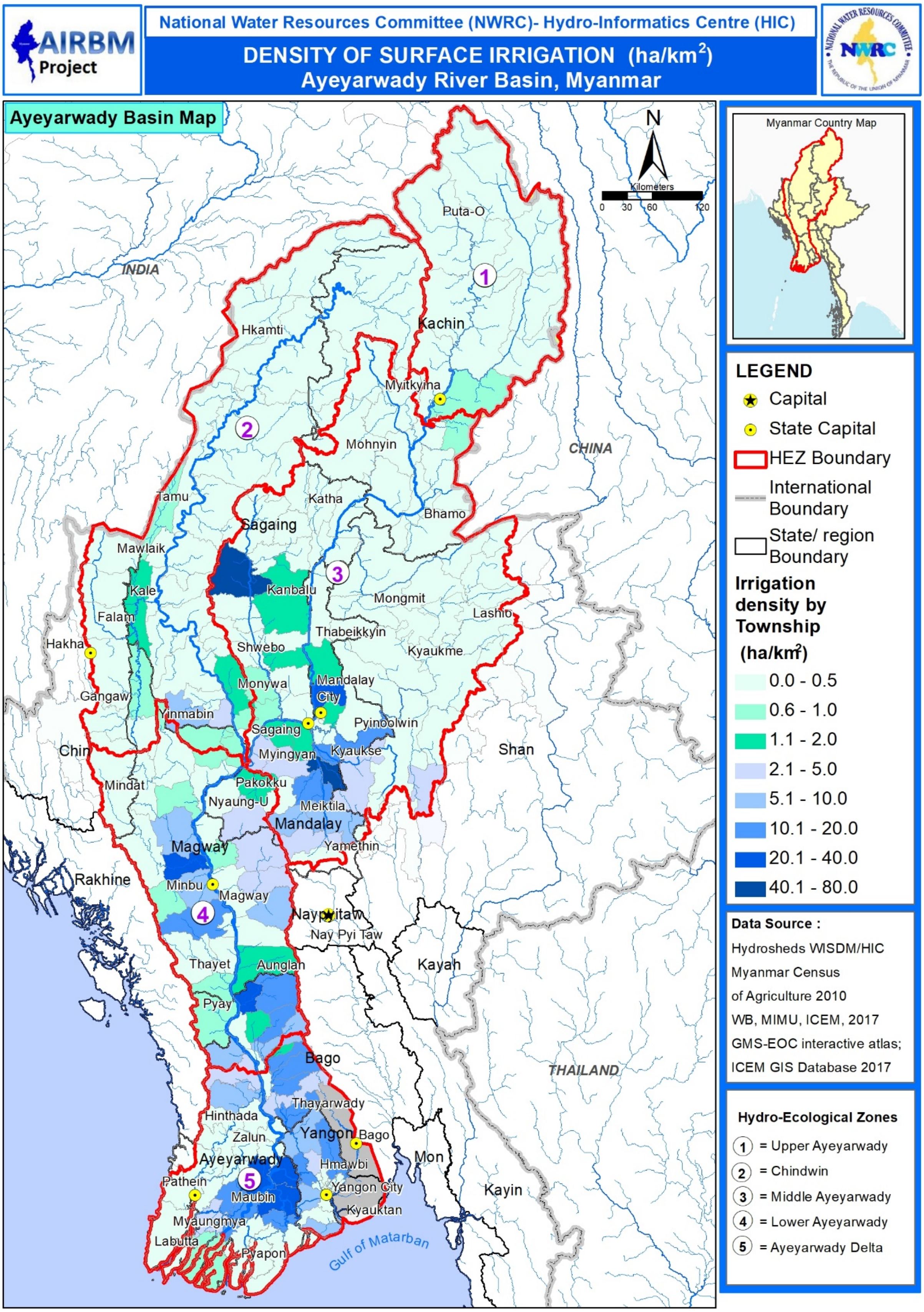


Figure 217 - Irrigation density

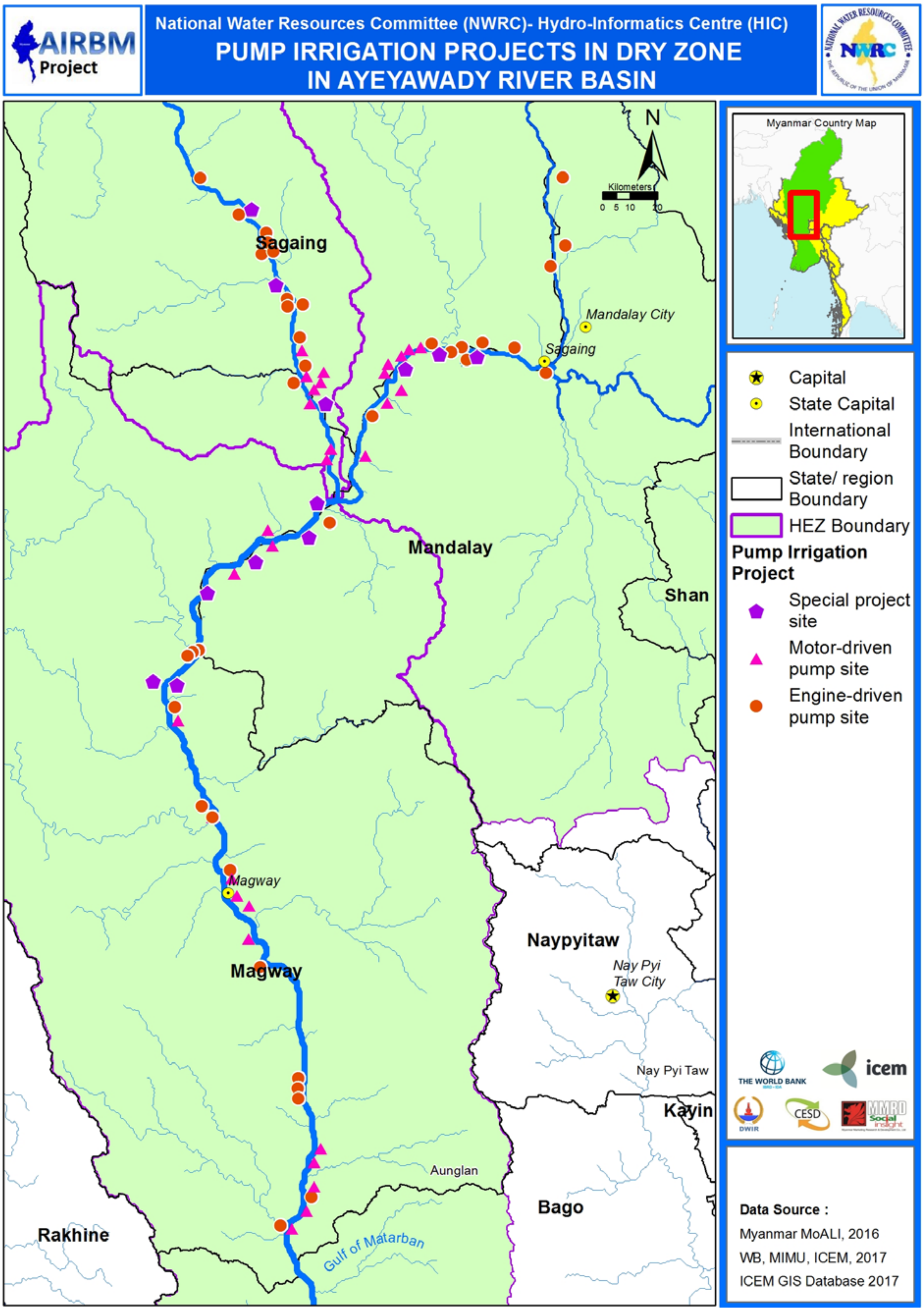


Figure 218 - Location of river lift irrigation services

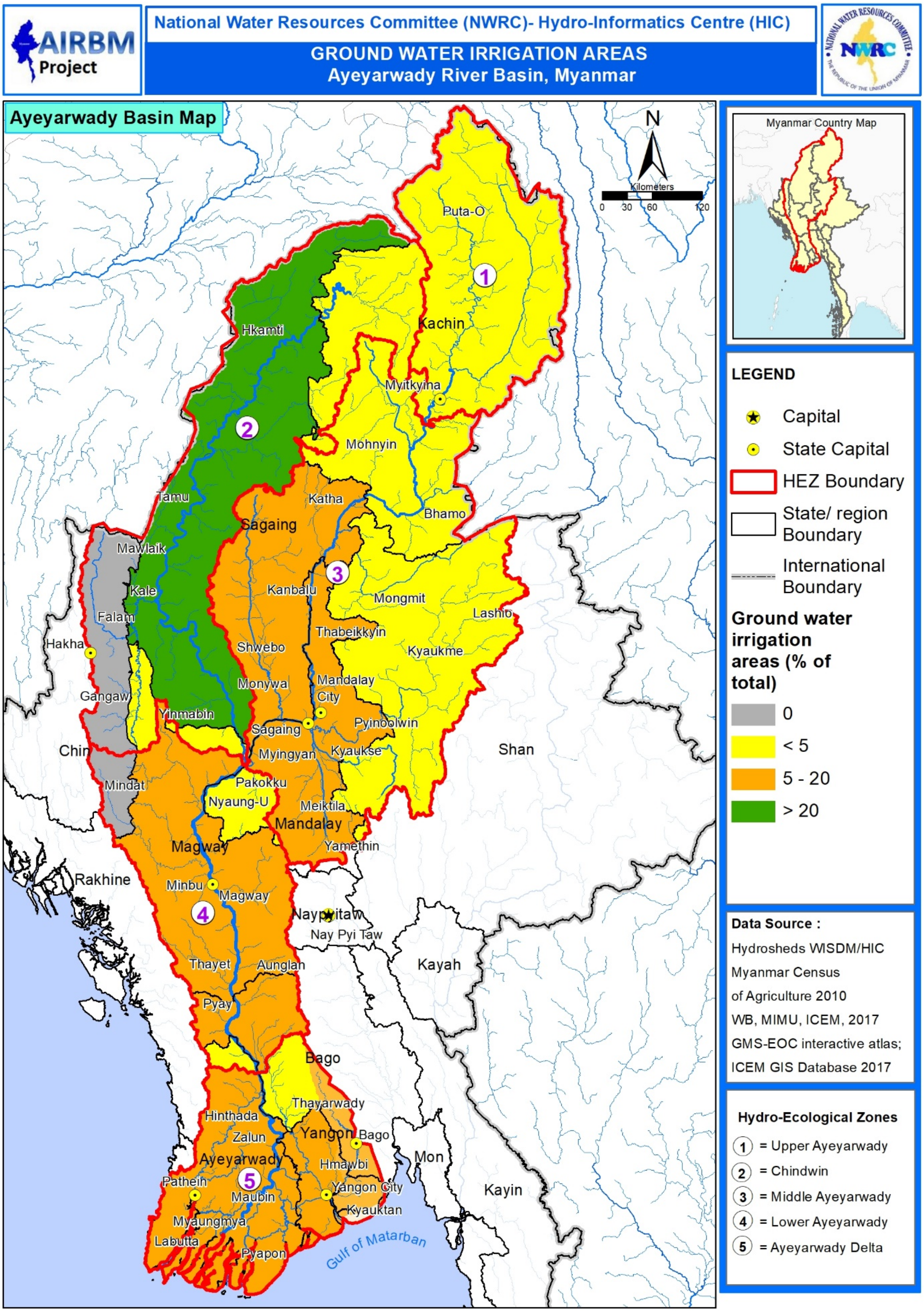


Figure 219 - Groundwater irrigation

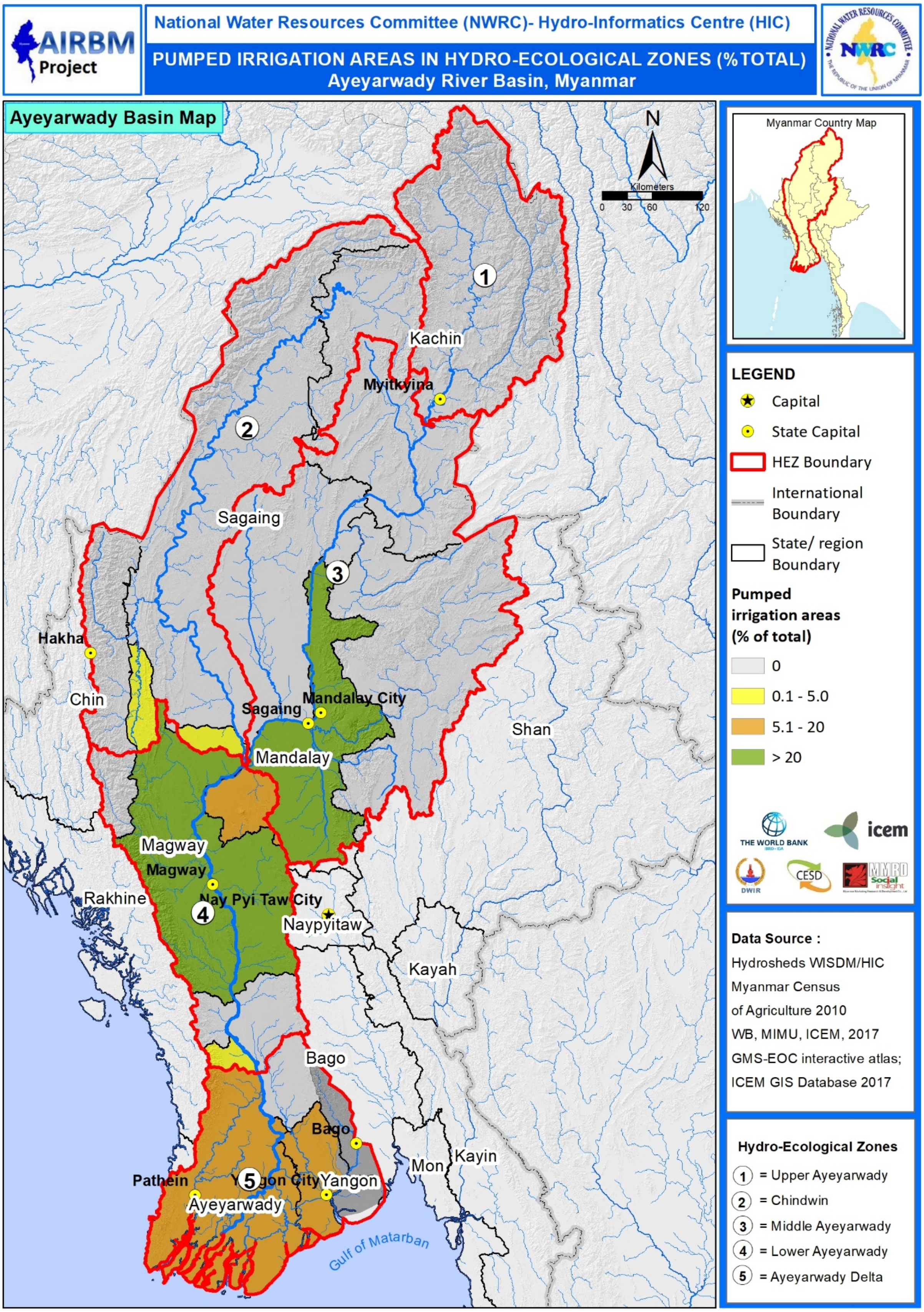


Figure 220 - Pumped Irrigation

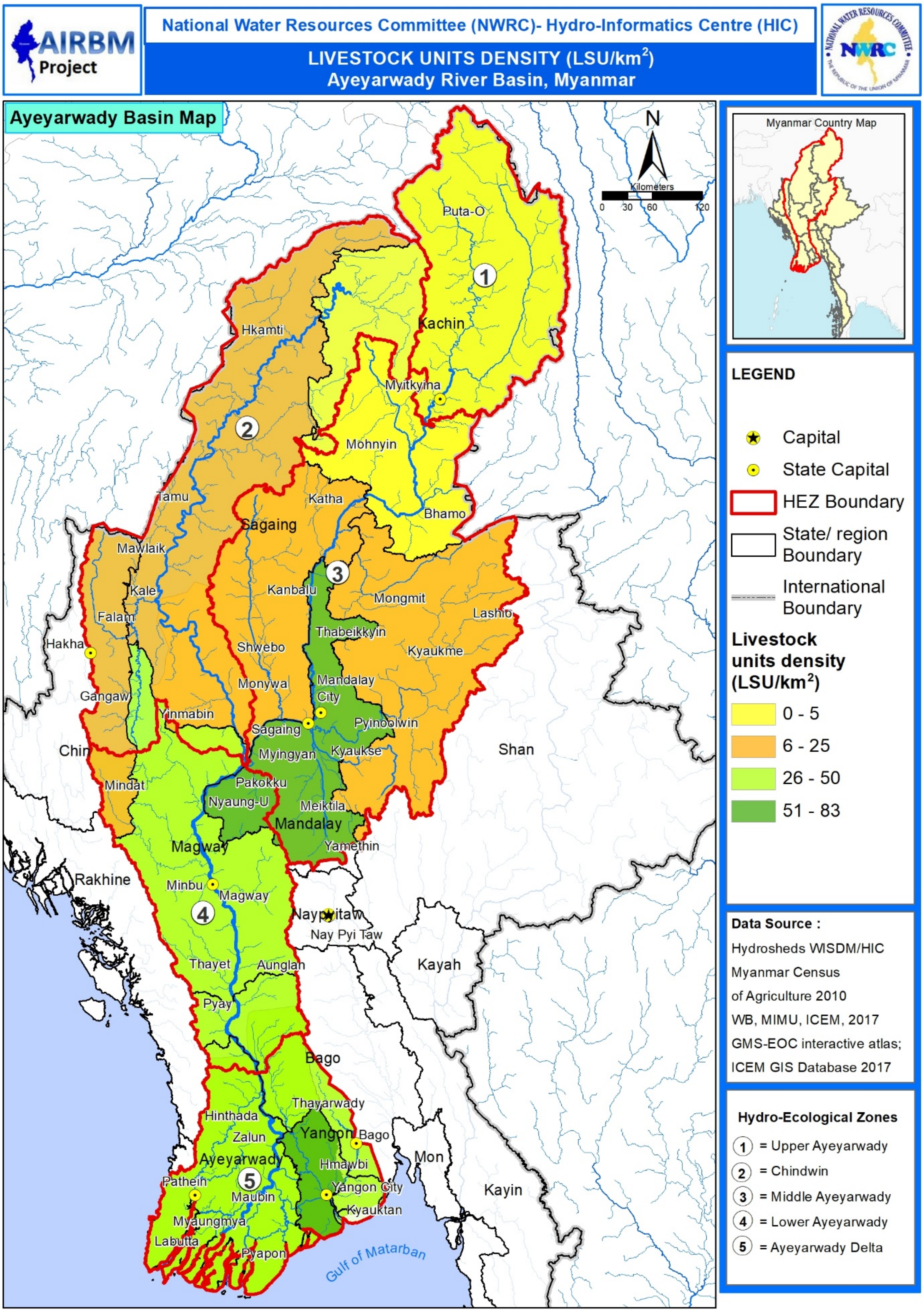


Figure 221 - Livestock density

ANNEX VII - FOREST LOSS DATA FOR THE AYEYARWADY BASIN

Table 136 - Areas of forest and land use by hydro-ecological zone and state/regions in the Ayeyarwady Basin

(FD, 2015)

Ayeyarwady Basin HEZ	State/ regions	Closed forest	Open forest	Other wooded land	Cropland	Other lands	Settlements	Wetlands	Mangroves	Snow	Water	Grasslands	Total (km²)
		1	2	3	4	5	6	7	8	9	10	11	
Upper Ayeyarwady	Kachin	26,395.5	26,577.5	11,521.9	5,552.1	465.0	112.8	-	-	1,290.9	527.4	-	**72,443.0**
Chindwin	Chin	3,416.8	5,012.0	3,644.9	480.4	-	3.3	-	-	-	16.2	-	**12,573.6**
	Kachin	6,159.2	4,639.0	3,763.6	1,815.9	271.1	11.7	-	-	-	108.9	30.8	**16,800.3**
	Magway	565.2	454.6	1,288.8	2,913.3	28.9	7.6	-	-	-	67.9	-	**5,326.3**
	Sagaing	13,371.1	15,235.0	21,801.8	10,219.3	1,042.5	80.3	-	-	-	552.0	-	**62,302.1**
Middle Ayeyarwady	Magway	0.0	-	1.1	51.0	3.3	-	-	-	-	4.4	-	**59.9**
	Sagaing	2,979.9	2,445.1	8,669.2	16,224.0	81.4	99.4	26.1	-	-	558.7	-	**31,083.8**
	Shan	6,604.5	11,455.4	18,651.5	9,882.3	0.1	28.0	2.1	-	-	183.6	-	**46,807.4**
	Mandalay	1,990.3	2,835.9	5,700.5	13,396.9	162.2	145.9	4.2	-	-	410.7	-	**24,646.5**
Lower Ayeyarwady	Ayeyarwady	110.4	369.6	479.5	466.1	41.3	2.9	-	-	-	45.7	-	**1,515.6**
	Bago	556.1	1,877.8	2,874.0	3,447.4	40.4	65.4	-	-	-	234.4	-	**9,095.4**
	Chin	559.5	2,653.7	638.7	45.9	-	-	-	-	-	0.0	-	**3,897.8**
	Magway	1,096.7	4,718.1	16,399.0	16,210.8	346.2	97.3	-	-	-	509.1	-	**39,377.2**
	Sagaing	0.9	24.1	95.1	26.4	0.9	-	-	-	-	0.0	-	**147.4**
	Mandalay	4.7	137.3	1,907.8	2,921.7	58.7	42.6	-	-	-	43.5	-	**5,116.2**
Delta	Ayeyarwady	616.3	1,417.7	6,979.7	19,833.3	489.1	71.2	0.9	710.5	-	984.3	-	**31,102.9**
	Bago	155.4	752.8	1,399.9	2,643.9	6.1	24.2	-	-	-	146.7	-	**5,129.0**
	Yangon	100.4	722.6	1,685.2	3,448.4	284.0	350.9	-	-	-	312.5	-	**6,904.1**
Total		**64,683.8**	**81,330.1**	**107,505.2**	**109,583.1**	**3,326.1**	**1,149.4**	**40.3**	**718.5**	**1,299.9**	**4,716.2**	**41.8**	**374,328.4**

Table 137 - Area forest types by hydro-ecological zone and state/region in the Ayeyarwady River Basin, 2014

(Bhagwat et al 2017)

Ayeyarwady Basin HEZ	State/region	Degraded forest (10% - 80% canopy)*	New non-forest	Water	Non-forest (<10% canopy)	Intact forest (>80% canopy)	Snow, ice or cloud	Plantation	Total area (km²)
1. Upper Ayeyarwady	Kachin	21,212	334	771	8,295	38,804	1,076	1,672	**72,163**
2. Chindwin	Chin	6,763	171	22	882	4,809	-	1	**12,648**
	Kachin	3,020	331	143	598	12,511	-	164	**16,767**
	Magway	1,565	73	57	3,116	488	-	55	**5,352**
	Sagaing	19,486	1,221	591	12,380	28,649	-	235	**62,563**
3. Middle Ayeyarwady	Magway	0	0	3	57	0	-	-	**60**
	Sagaing	7,873	400	603	18,831	3,219	-	188	**31,115**
	Shan	24,121	1,475	170	13,829	5,399	-	1,647	**46,641**
	Mandalay	4,678	304	478	17,558	1,284	-	335	**24,637**
4. Lower Ayeyarwady	Ayeyarwady	387	3	31	989	109	-	1	**1,519**
	Bago	2,360	51	212	5,954	500	-	10	**9,087**
	Chin	1,972	23	2	202	1,711	-	6	**3,917**
	Magway	10,841	183	551	26,166	1,693	-	69	**39,503**
	Sagaing	115	4	-	16	12	-	1	**148**
	Mandalay	226	0	55	4,842	6	-	0	**5,129**
5. Delta	Ayeyarwady	4,931	254	1,115	23,172	1,377	-	235	**31,085**
	Bago	1,284	16	84	3,596	124	-	30	**5,133**
	Yangon	1,274	19	182	5,227	126	-	69	**6,897**
Total		**112,109**	**4,862**	**5,071**	**145,710**	**100,821**	**1,076**	**4,717**	**374,363**

Table 138 - Area forest cover(canopy cover (Cc) %) in 2015 by hydro-ecological zone and state/region in the Ayeyarwady Basin

(Hansen et al., 2013)

Ayeyarwady Basin HEZ	State/region	Other land	Regenerated forest (Cc 0.1 - 0.3)	Opened forest (Cc 0.3 - 0.5)	Medium forest (Cc 0.5 - 0.7)	Closed forest (Cc 0.7 - 0.9)	Very closed forest (Cc >0.9)	Water body	Total area (km²)
1. Upper Ayeyarwady	Kachin	11,040.3	1,314.8	2,050.5	3,905.2	27,881.7	27,606.8	416.6	**74,216.0**
2. Chindwin	Chin	1,805.3	650.4	1,054.8	3,371.6	5,207.1	501.7	9.3	**12,600.3**
	Kachin	925.3	100.4	163.1	458.5	6,445.9	9,091.5	58.5	**17,243.3**
	Magway	3,333.0	273.6	406.8	1,005.7	249.0	4.2	32.8	**5,305.0**
	Sagaing	14,161.4	1,143.0	1,814.7	6,817.2	23,608.8	15,342.3	461.6	**63,349.0**
3. Middle Ayeyarwady	Magway	56.1	0.0	0.0	-	-	-	3.3	**59.4**
	Sagaing	18,497.3	1,025.4	1,291.8	3,161.7	5,908.1	803.7	549.9	**31,237.9**
	Shan	12,698.5	2,170.0	3,621.3	11,205.4	15,365.1	1,481.4	134.2	**46,675.8**
	Mandalay	16,808.0	711.6	921.4	2,685.3	2,807.0	147.5	380.8	**24,461.5**
4. Lower Ayeyarwady	Ayeyarwady	907.9	104.7	72.3	246.8	110.4	1.5	29.5	**1,473.2**
	Bago	5,508.4	469.3	387.1	1,140.1	1,040.4	92.2	225.8	**8,863.4**
	Chin	524.6	135.2	198.5	638.1	1,948.4	412.3	1.8	**3,858.9**
	Magway	27,987.9	1,613.3	1,586.2	3,700.8	3,188.9	327.3	361.2	**38,765.6**
	Sagaing	58.0	15.6	30.3	41.3	1.5	0.0	0.0	**146.7**
	Mandalay	4,919.6	49.1	27.2	15.3	1.3	0.0	47.1	**5,059.6**
5. Delta	Ayeyarwady	23,161.6	1,094.4	818.1	1,821.9	2,054.7	250.7	722.8	**29,924.3**
	Bago	3,451.2	175.2	164.0	438.0	562.7	132.4	53.2	**4,976.5**
	Yangon	4,999.5	282.8	183.5	380.7	504.0	139.1	166.3	**6,655.8**
Total		**150,844.0**	**11,328.7**	**14,791.4**	**41,033.5**	**96,885.2**	**56,334.6**	**3,654.7**	**374,872.2**

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