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Rice productivity in Myanmar

Assessment of the 2021 monsoon and outlook for 2022

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ABSTRACT

We analyze rice input and productivity data for the monsoon seasons of 2020 and 2021 from the Myanmar Agriculture Performance Survey (MAPS). The survey covers plots of 2,672 rice producers, spread over 259 townships in all states/regions of the country. We find that:

1. Rice productivity at the national level during the monsoon of 2021 decreased on average by 2.1 percent compared to the monsoon of 2020. Considering estimated area reductions, national paddy production decreased by 3.4 percent compared to the monsoon of 2020.
2. Some areas performed substantially worse. Rice yields were low and declined significantly in Kayah and Chin, two conflict-affected states that have shown the highest levels of food insecurity in recent assessments.
3. Prices for most inputs used in rice cultivation increased significantly between these two seasons. Prices of urea, the most important chemical fertilizer used by rice farmers, increased by 56 percent on average and mechanization costs increased by 19 percent.
4. Paddy prices at the farm increased by 8 percent, significantly less than input prices, squeezing rice farmers' profits during the monsoon of 2021.

Despite the substantial hurdles in production and marketing due to the political crisis and international market developments, the results of the Myanmar Agricultural Performance Survey show the overall resilience of rice production during the monsoon of 2021. While the rice sector has been a source of stability in the country, the situation for future crop seasons is however concerning given further increases in input prices (especially fertilizer), the overall reduced profitability of rice farming, the reduced coping strategies remaining for rice farmers, and currency policy changes by the military government.

1. INTRODUCTION

Rice is an extremely important product for farmers' livelihoods and for food security in Myanmar. Rice is the main staple, accounting for 51 and 62 percent of urban and rural calories consumed, respectively, making it crucial for food security in the country.[1] It is also the predominant crop for a large number of farmers, especially during the monsoon season, as well as an important export product. However, large international changes in commodity markets and twin local crises – COVID-19 and political problems due to the military take-over – have hit the agri-food sector of Myanmar hard and have raised doubts on the performance of the agricultural sector overall and the rice sector in particular (MAPSA 2021c, Goeb et al. 2021, Boughton et al. 2021).

Internationally, there have been large changes in commodity markets in 2021 and 2022. International fertilizer prices have increased by 125 percent between January 2021 and January 2022 due to high prices of feedstock (Hebebrand and Laborde 2022). Moreover, international shipping costs in 2021 were substantially higher due to a global shortage of containers, which was especially problematic in Asia due to COVID-19 related trade reductions. International freight costs in the Southeast Asian region in 2021 were estimated to be two to four times higher than during normal times (USDA 2021). Following Russia's invasion of Ukraine in February, fertilizer prices have increased even further, given that Russia and Ukraine are major suppliers of feedstock for fertilizers (Hebebrand and Laborde 2022). Fertilizer prices have increased by 17 percent between January and March 2022. The higher prices of fertilizers are leading to global worries about food security.[2]

Locally, the COVID-19 and political crises have created unprecedented challenges to the functioning of agricultural value chains and the agri-food system. The COVID-19 crisis has led to large income declines in the country overall and to substantial disruptions in Myanmar's agri-food system (Boughton et al. 2021; Headey et al. 2020). The political crisis has caused substantial problems in the banking and finance sector, in international trade, and in the local transport sector, among others (USDA 2021). Moreover, the currency of Myanmar, the kyat (MMK), has been rapidly depreciating. At the farm level, the political crisis in 2021 led to lower credit availability for farmers, a decrease in farm prices for some crops, and more uncertain agricultural profitability (MAPSA 2021c). However, updated representative assessments of farm-level effects have been missing.

The assessment on farmers' rice productivity during the monsoon of 2021 presented in this paper is based on data from the Myanmar Agriculture Performance Survey (MAPS) that was conducted with 2,672 rice producers, spread over 259 townships in all states/regions of the country, over the period February 2022 – March 2022. Detailed questions were asked to farmers about their background, input use and input prices, farm management practices, rice output and output prices, and natural and other shocks during the monsoon of 2020 and 2021.[3] This Working Paper presents the results from this assessment and then discusses implications of the findings.

The structure of the paper is as follows. In section 2, we present the data collection method and descriptive statistics. Section 3 looks at prices of inputs and outputs over the last two monsoons. In Section 4, results on input use and farm management practices in rice production are presented. Section 5 looks at the prevalence of natural and other shocks for these two seasons. Given the large changes in fertilizer markets in the two seasons, we then assess the link of fertilizer use with rice productivity in Section 6. Section 7 present the results on rice productivity and production. We finish in the last section with conclusions and implications.

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[1] Estimated in 2015 (based on Myanmar Poverty, Livelihood, and Consumption Survey).

[2] For food markets, we note important price increases for some major staples. Grain prices in March 2022 were on average 23 percent higher than a year earlier, especially driven by high price increases of wheat (Hebebrand and Laborde 2022).

[3] In this paper, rice refers to rice in paddy form throughout.

2. DATA

The Myanmar Agricultural Performance Survey (MAPS) is a sub-sample of 12,100 households interviewed by phone during the first round of the Myanmar Household Welfare Survey (MHWS) that was fielded in the beginning of 2022 (MAPSA 2022a). In the MHWS, information was collected, among others, on the background of these households, welfare indicators, and livelihoods. The follow-up MAPS focused on the agricultural activities of 5,465 households that were identified as crop farmers in the MHWS. This survey was implemented by phone by Myanmar Survey Research (MSR) over the period February 11th until March 25th, 2022.[4] Approximately 71 percent of the farmers (3,891) that were interviewed in the first round of the MHWS could be reached for a second follow-up interview.[5]

Of the 3,891 crop farmers in the MHWS, 2,672 farmers (69 percent) cultivated rice in the 2021 monsoon (Table 1). The number of rice farmers interviewed by township is shown in Figure 1, indicating their spread in the country. The analysis that is presented in this paper focuses on these rice farmers in particular. Table 1 shows to what extent the number of rice farmers interviewed varies by rice area cultivated by state and region using the most recent paddy rice areas cultivated as estimated by the Ministry of Agriculture, Livestock, and Irrigation (MoALI). MoALI evaluated the rice area cultivated during the monsoon of 2020 at 14.6 million acres. This implies that with the MAPS, 1.8 rice farmers were interviewed, on average, for each 10,000 acres of rice cultivated in the country. This ratio varies from a low of 1.0 in the Ayeyarwady region to 4.9 in the Mandalay region.

Table 1: Sample rice farmers, MAPS

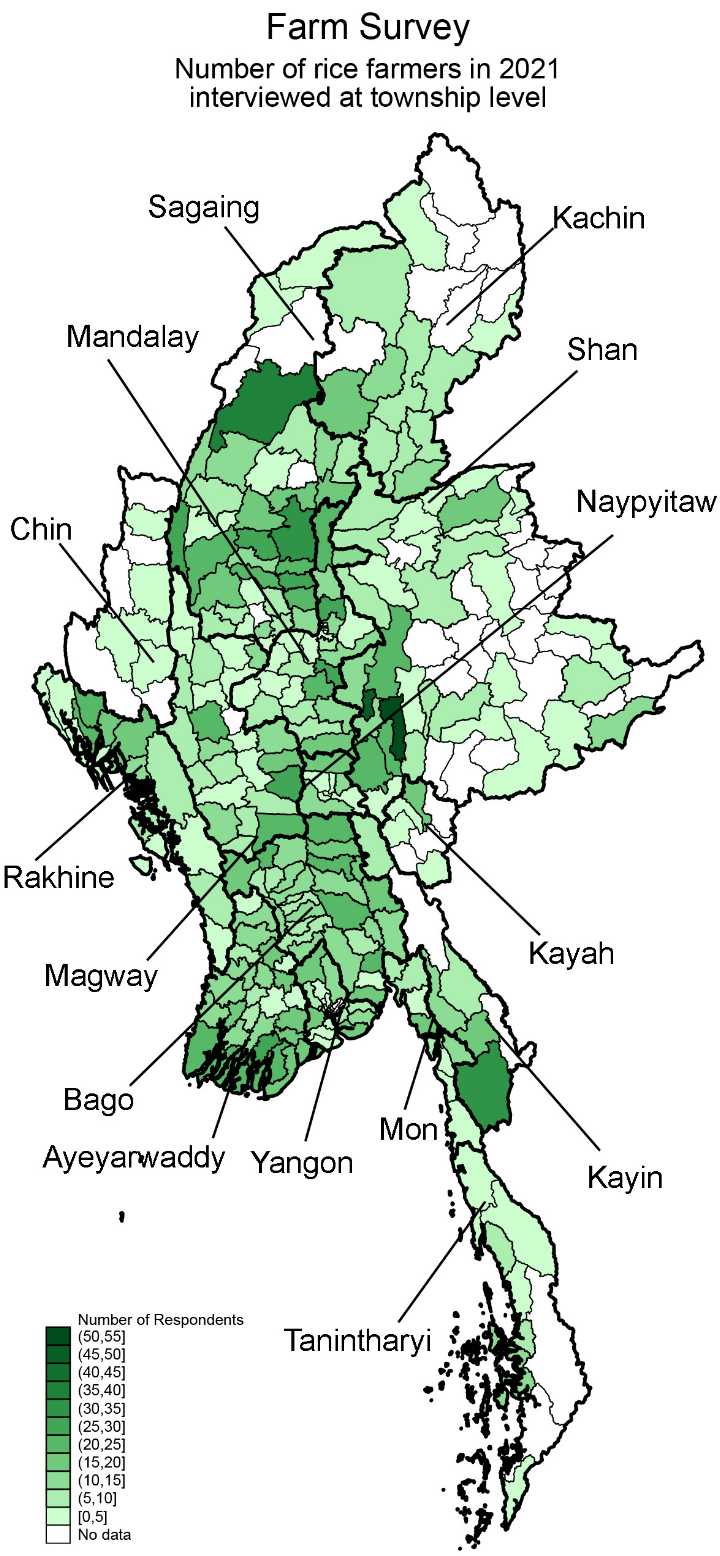
	MAPS			Paddy harvested area	Farmers
	Crop	Rice Farmers		2020 (1,000 acres)	interviewed per
	farmers	2020	2021	MoALI	10,000 acres
By State/Region					
Kachin	108	88	93	486	1.91
Kayah	45	31	26	82	3.16
Kayin	116	86	85	430	1.98
Chin	47	8	8	69	1.17
Sagaing	616	469	473	1,552	3.05
Tanintharyi	77	47	46	224	2.06
Bago	432	396	394	2,683	1.47
Magway	422	220	226	579	3.90
Mandalay	496	231	238	487	4.89
Mon	123	71	72	685	1.05
Rakhine	158	134	132	980	1.35
Yangon	150	127	125	1,166	1.07
Shan	550	324	326	1,262	2.58
Ayeyawady	472	369	363	3,751	0.97
Nay Pyi Taw	79	66	65	166	3.91
By agro-ecological zone					
Hills and mountains		537	538	2,329	2.31
Dry zone		986	1,002	2,784	3.60
Delta region		963	954	8,284	1.15
Coastal zone		181	178	1,203	1.48
Total	3,891	2,667	2,672	14,601	1.83

Source: Authors' calculations based on MAPS

[4] To avoid fraud and to ensure quality of data collected, MSR carried out a series of quality control procedures. The average length of the MAPS was 51 minutes.

[5] 1131 respondents could not be reached (no answer or lack of power), 326 refused, 70 terminated mid-interview, 40 were not eligible and 10 could not be interviewed because of language barriers.

Figure 1: Sample of rice farmers, MAPS



Source: Authors' calculations based on MAPS

To assure that crop farmers are representative of the crop farming population in their state or region, a weighting factor was calculated building on the method used for the MHWS (MAPSA 2022b). We use the share of the respondents that reported living in a household where crops were harvested in the past 12 months as our measure of a crop farming household. The share of crop farming households was also calculated based on the same question in the 2017 Myanmar Living Conditions Survey (MLCS) implemented by the Myanmar Central Statistical Organization (CSO), UNDP, and The World Bank (CSO, UNDP & World Bank 2019), which was the last nationally representative socioeconomic survey conducted in Myanmar. Basic weights are calculated to match the MAPS numbers to this crop farming population of the MLCS. The basic weights further correct for education bias in the sample (based on MLCS numbers) and make sure that we match overall population numbers of the 2019 Inter-Censal Survey (at urban/rural and State and Regional level) (DOP, UNFPA 2020). An entropy correction approach was then implemented to additionally correct for large farm bias (using 5 land sizes) as well as adjust the share of women-adult-households in the farm population to the MLCS number.

The MAPS collected information on household characteristics, overall area cultivated, crops grown, rice production and sales, agricultural input and output prices, and the incidences of natural and other shocks. In this paper, we focus in particular on the information that was collected on the biggest rice plot of rice producers in the monsoon of 2020 and 2021. Data for these plots were collected on input use and farm management practices, such as the use of seeds, agro-chemicals, fertilizers, labor and mechanization and rice output. Farmers were also asked to estimate overall monetary input expenditures on these plots. While we collected these data from 259 townships and 2,672 households [6], caution is warranted in interpretation and extrapolation to national and state/region-wide rice production as we only collected information on the largest rice plot.

We divide the country into four major agro-ecological zones that are commonly used in Myanmar and present our results at that level.[7] The average farm size of the interviewed rice farmers was 7.1 acres (Table 2). The biggest rice farms are seen in the Delta region (8.9 acres) while farms in the Hills and Mountains agro-ecological zone are substantially smaller (5.9 acres). Three-quarters of he cultivated land of the average rice farmer was used for paddy rice (5.3 acres). Nationally, the size of the largest plot was on average 1.2 acres while the median was 1. Plots are relatively smaller in the Hills and Mountains zone compared to the rest of the country. A large majority of rice plots at the national level are in lowlands (90 percent), whereas in the Hills and Mountains zone more than a quarter of rice plots are in the uplands.

The main farm management decision maker for these rice farms was male in 62 percent of the cases and 42 years old on average. Two percent of these agricultural decision makers had no education at all while 86 percent indicated that they had completed standard levels from 1 to 10. Five percent reported that they had obtained a bachelor’s degree. The number of household members working on the farm was on average 2.2. Like results from earlier surveys, there were relatively more adult males working on the farm (62 percent of all labor) than females (38 percent of all labor) (Lambrecht et al. 2021), while work by children (defined as less than 15 years old) was reported by respondents to be less important.

[6] Five households reported to cultivate rice in 2021, but not in 2020. Given the small number, no correction for this attrition was made in presented statistics.

[7] Delta (Ayeyawaddy, Bago, Mon, Yangon); Coastal (Rakhine, Tanintharyi); Central Dry (Mandalay, Magwe, NPT, Sagaing); Hills and Mountains (Chin, Kachin, Kayah, Kayin, Shan).

Table 2: Descriptive statistics of rice farmers, MAPS

		Monsoon 2021				
	Unit	National	Hills	Dry	Delta	Coastal
Total number of rice farmers	Number	2,672	538	1,002	954	178
Background rice farm						
Average size farm - mean	Acres	7.1	5.9	6.4	8.9	6.4
Average size rice area - mean	Acres	5.3	3.0	4.2	7.9	5.3
Size largest plot - mean	Acres	1.2	1.0	1.1	1.4	1.5
Size largest plot - median	Acres	1.0	0.7	1.0	1.0	1.0
Land type largest plot						
Upland	%	9.9	29.6	5.5	2.2	5.1
Lowland	%	90.1	70.4	94.5	97.8	94.9
Background of main farm management decision maker of rice farms						
Age	Years	42	40.0	43.0	42.7	42.5
Gender	% male	61.7	63.8	66.9	66.5	68.5
Highest level of education achieved						
None	%	2.1	3.6	1.7	1.2	3.1
Standard 1-10	%	86.0	84.3	85.8	86.2	90.3
Bachelor	%	5.5	5.1	5.6	6.4	2.0
Other	%	6.5	7.0	6.9	6.2	4.6
Household members working regularly on the rice farm						
Adult male - mean	Number	1.32	1.41	1.32	1.23	1.41
Adult female - mean	Number	0.89	1.08	1.06	0.62	0.78
Children - mean	Number	0.01	0.02	0.01	0.01	0.00

Source: Authors' calculations based on MAPS

3. INCENTIVES FOR RICE CULTIVATION - INPUT AND OUTPUT PRICES

Input prices for rice farmers have changed dramatically over the last two monsoons (Table 3). First, chemical fertilizer prices reflected by the price of urea, the most important fertilizer used by rice farmers, have increased by 56 percent on average (the median by 68 percent) during the monsoon of 2021 compared to a year earlier. These high fertilizer price increases were mostly driven by international price changes, by the depreciation of the local currency, and increased fuel and transportation costs locally (MAPSA 2021a). Table 3 also shows that urea prices are relatively higher in the Coastal zone and the Hills and Mountains areas compared to the rest of the country, likely reflecting distances from the entry points of fertilizer imports from abroad (MAPSA 2021a).

Second, agricultural mechanization has rapidly taken off in the last decade and is now being used by a large majority of farmers (Belton et al. 2021). As a measure of the costs of mechanization, Table 3 presents the prices for plowing 1 acre of land by a four-wheel tractor. Farmers report that those costs have increased by 19 percent on average, mostly reflecting the higher costs of fuel in the country over these two seasons. However, a survey of mechanization service providers during the monsoon of 2021 showed that they faced financial challenges and fears of foreclosure on machinery loans due to the worsening demand in the country overall (MAPSA 2021b), possibly contributing to further price increases to farmers.

Third, the use of wage labor in agricultural activities is very common in Myanmar. It has been shown that wage levels in the past (before the COVID-19 pandemic) had been increasing fast because of the increasing possibilities of alternative employment in cities and neighboring countries. This partly explains the rapid adoption of agricultural mechanization in the country (Belton et al.

2021). However, this increase in wages has come to a halt, seemingly due to mobility restrictions linked to COVID-19 as well as the widespread economic problems because of the political crisis (World Bank 2022, MAPSA 2021c). Table 3 shows that average daily wages of hired labor of men and women increased by 7 percent while median wages did not change, in nominal terms, over the two seasons. However, wages decreased in real terms as inflation has been high in the country. MAPSA (2022a) estimated, based on a large food vendor survey in different parts of the country at the same time as the MAPS, that the costs of a typical food basket increased by 41 percent compared to a year earlier, substantially higher than these changes in wages. While bad for the welfare of these workers, these wage labor costs did not increase substantially for farmers.

While we see increases in prices for most agricultural inputs, we see a smaller change in output prices at the time of the survey, impacting the profitability of rice production. Table 3 shows that at the national level average prices for paddy increased by 8 percent (the median changed by 7 percent). Paddy prices were relatively lower in the Delta region and the Coastal zones, likely reflecting their surplus status and the distances from those communities to end-markets in big cities (such as Yangon and Mandalay) as well as export markets (rice is shipped out from Yangon or through land borders).

Table 3: Input and output prices in paddy rice cultivation, monsoon 2020 and 2021

	Unit	Monsoon 2020 National	National	Hills	Monsoon 2021 Dry	Delta	Coastal
Inputs							
Urea price (MMK/kg)	Mean	805	1,257	1,253	1,320	1,174	1,393
	Median	740	1,240	1,240	1,300	1,160	1,500
Costs plowing 1 acre (4-wheel) (MMK)	Mean	29,010	34,503	40,161	30,906	32,291	46,900
	Median	25,000	30,000	35,000	30,000	30,000	45,000
Daily wage man (MMK)	Mean	6,200	6,666	6,835	6,224	6,615	8,083
	Median	6,000	6,000	6,000	6,000	6,000	8,000
Daily wage woman (MMK)	Mean	4,972	5,315	5,654	5,076	5,120	6,085
	Median	5,000	5,000	5,000	5,000	5,000	6,000
Output							
Paddy price (MMK/kg)	Mean	351	380	401	401	362	347
	Median	335	359	360	383	340	335

Source: Authors' calculations based on MAPS

4. INPUT USE AND FARM MANAGEMENT PRACTICES

In this section, we look at input and farm management practices used in paddy cultivation, including seeds, agro-chemical and fertilizer use, and labor and mechanization as well as assess overall commercial inputs. Rice farmers in Myanmar predominantly rely on their own saved rice seeds from the previous harvest (Table 4). For the monsoon of 2020, 44 percent of the seed planted was own saved seeds, 31 percent of the rice farmers indicated that they bought seeds from agri-input suppliers or the government, while 25 percent bought them from other farmers. During the most recent 2021 monsoon, farmers relied more on their own seeds (50 percent of farmers) and purchased less seeds from agri-input retailers or the government (26 percent) compared to the previous season. Purchased seeds are usually improved seeds. The quality of reused seeds typically worsens the longer they are used by farmers suggesting that this decreased reliance on the market likely leads to lower rice yields overall (Spielman and Kennedy 2016; Denning et al. 2013).

We also note strong regional differences in the source of rice seeds. Farmers use less purchased seeds in the Coastal areas while rice farmers in the Dry Zone rely the most on purchased seeds. It is surprising that the market-oriented Delta region – the major rice bowl – is relying less on purchased seeds. Only 21 percent of the farmers bought their seed from an agri-input dealer while 54 percent of the farmers relied on seed obtained from their previous harvest.

Table 4 also shows the reported rice varieties used by farmers. There were few changes in varieties used between the two seasons. While there are no clear dominant seed varieties in Myanmar, the most prevalent variety at the national level – as reported by these farmers – was Emata (used by 55 percent of the farmers during the monsoon of 2021). In the Dry Zone, this was used by 62 percent of the farmers. Letywesin was reported to have been grown by 27 percent of the farmers while the higher valued (and lower yielding) Pawsan varieties were grown by 15 percent. The latter were especially important in Coastal areas (49 percent of the rice farmers) and the Delta region (20 percent). Figure 2 shows the spread of the different rice varieties for each state and region.

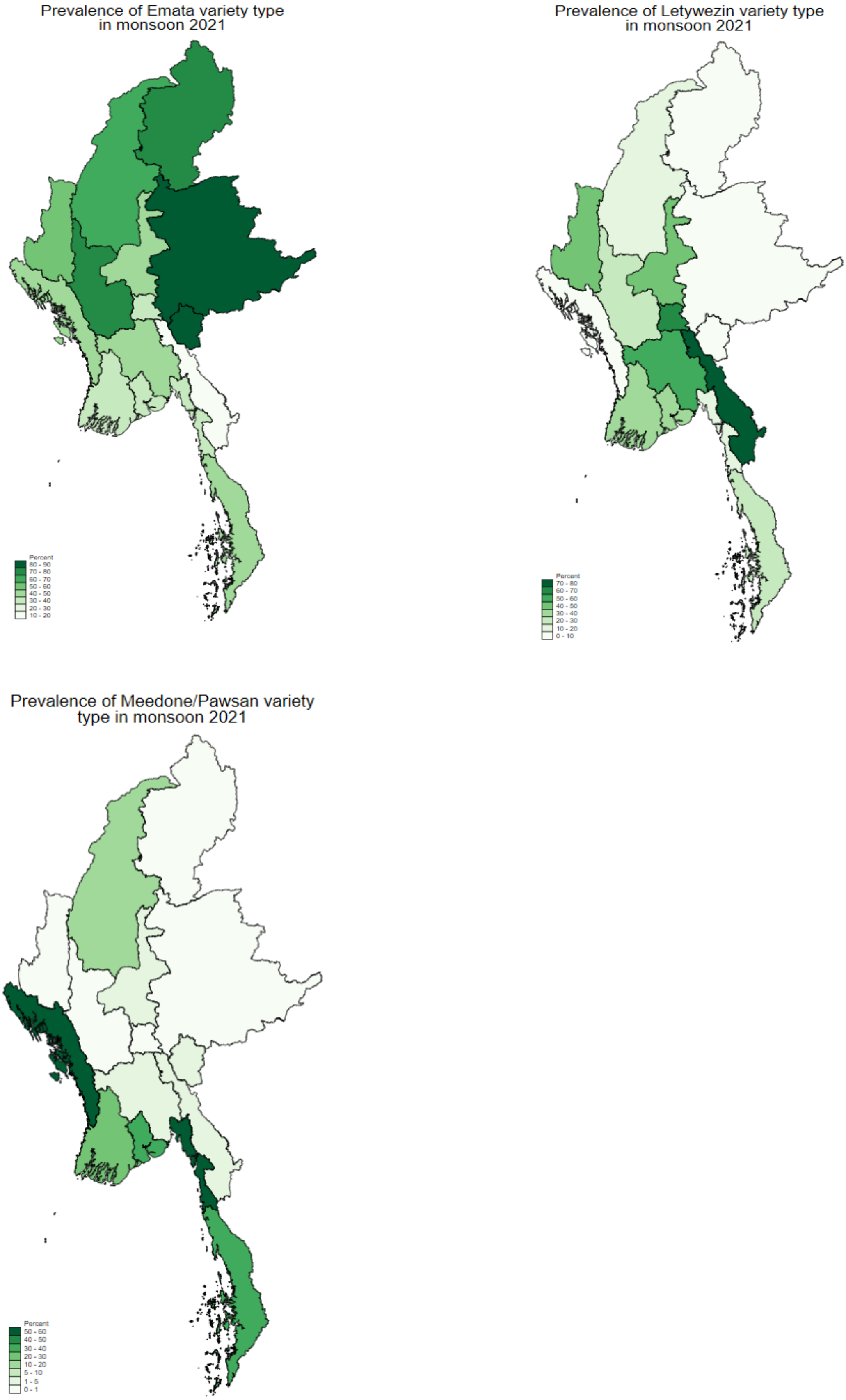
Table 4: Seed use

		Monsoon 2020	Monsoon 2021				
	Unit	National	National	Hills	Dry	Delta	Coastal
Seed source							
Purchase from agri-input dealer or government	%	30.7	25.9	28.4	32.8	20.5	14.0
Purchased from other farmer	%	24.7	23.0	21.2	22.9	25.2	18.9
Left-over (unused) purchased seed from last year	%	0.4	0.6	0.2	1.1	0.6	0.5
Saved (harvested) from last year	%	43.8	50.3	49.6	42.8	53.7	66.6
Other	%	0.4	0.2	0.6	0.3	0.0	0.0
Major seed variety							
Emata	%	54.1	55.1	75.5	62.1	37.8	42.8
Letywesin	%	26.6	26.9	16.0	26.8	39.5	5.6
Meedon/Pawsan	%	15.3	14.7	0.8	9.5	20.1	49.1
Ngasein	%	1.2	1.6	3.0	0.8	1.7	1.1
Sticky rice	%	2.3	1.2	3.1	0.6	0.6	0.7
Do not know	%	0.5	0.6	1.6	0.2	0.2	0.7

Source: Authors' calculations based on MAPS

Table 5 gives an overview of fertilizer and other agro-chemical use on the largest rice plot in the last two seasons. Despite the large price increase, we see relatively few changes in the share of farmers that use chemical fertilizers and other agro-chemicals, with 90 percent of the farmers using chemical fertilizer during the 2021 monsoon compared to 92 percent a year earlier. We note a slightly bigger drop in the farmers that have been using the most common fertilizer, urea, in the last season. While 76 percent of the farmers reported using urea on their largest plot during the monsoon of 2020, that dropped by 5 percentage points during the monsoon of 2021. The share of other types of fertilizers being used is much lower than urea and their usage decreased by a lesser amount over the two seasons. However, more farmers are using "other compound" fertilizer in the monsoon of 2021, increasing from 15 to 19 percent compared to the monsoon of 2020. We also see relatively small decreases in the share of households using organic fertilizers (dropping from 50 during the 2020 monsoon to 49 percent during the 2021 monsoon), lime/gypsum (from 11 to 9 percent), herbicides (54 to 53 percent), and other pesticides (from 44 to 41 percent).

Figure 2: Rice varieties used, monsoon 2021



Source: Authors' calculations based on MAPS

We further note that chemical fertilizer use is widespread in all agro-ecological zones. In the Dry Zone, 88 percent of farmers were using chemical fertilizer compared to 92 percent in Coastal areas. Organic fertilizer use is significantly higher in the Dry Zone, likely linked to the higher prevalence of livestock ownership in that area. The use of lime, gypsum, and herbicide is most prevalent in the Delta region.

Table 5: Agro-chemicals and fertilizer use on paddy rice cultivation

		Monsoon 2020	Monsoon 2021				
	Unit	National	National	Hills	Dry	Delta	Coastal
Chemical fertilizer							
Any chemical fertilizer	%	91.5	89.8	91.2	87.8	90.4	91.7
Urea	%	76.3	71.5	73.8	68.8	74.1	64.7
Ammonium sulphate	%	12.6	9.7	6.5	9.0	13.2	7.4
Compound 15_15_15	%	19.6	18.6	21.0	19.3	18.8	8.8
Other compound combined	%	14.7	19.4	22.4	21.2	17.4	12.1
Tsuper	%	10.6	8.9	11.4	4.6	7.7	23.0
Potash	%	2.1	2.0	2.5	1.1	2.6	1.9
Other fertilizer and agro-chemicals							
Organic fertilizer	%	50.0	48.9	46.0	61.1	44.1	29.7
Lime - gypsum	%	11.0	8.6	4.9	5.0	15.7	4.4
Herbicides	%	54.2	53.6	55.4	48.4	61.2	38.6
Other pesticides	%	43.6	41.5	50.4	37.5	43.0	26.8
Number of observations		2,657	2,661	533	998	954	176

Source: Authors' calculations based on MAPS

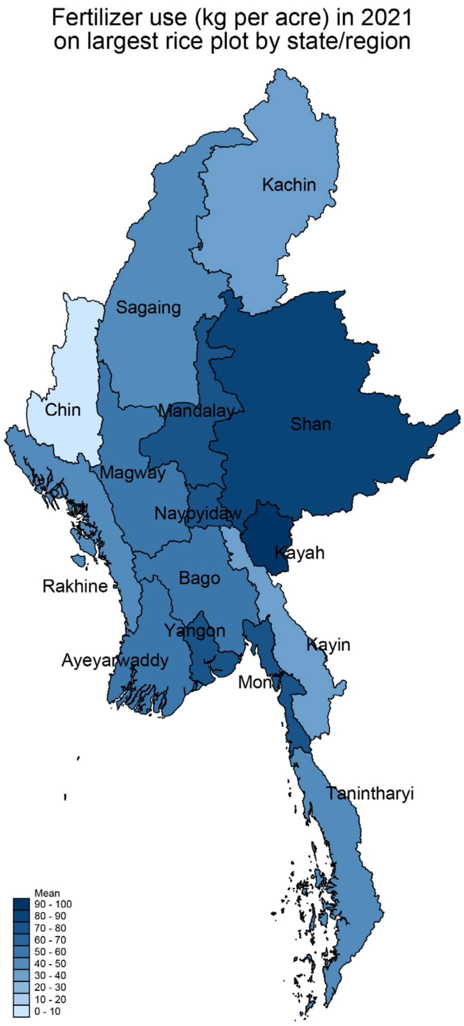
During the monsoon of 2021, rice farmers used 59 kgs of fertilizer per acre on average (Table 6). Despite the relatively large price increase, we only see a small decline, of 14 percent on average, in the amount of chemical fertilizer used between the two seasons, suggesting that chemical fertilizer is seen by farmers as a priority input for rice productivity. Urea is the most important fertilizer used on rice, making up 56 percent of all fertilizers used. Fertilizer use on rice differs between regions and states in the country (Figure 3). Fertilizer use on rice in the monsoon season is highest in the Hills and Mountains (69 kgs per acre) and lowest in the Coastal areas (46 kgs per acre).

Table 6: Chemical fertilizer use in paddy rice cultivation (kgs per acre)

		Monsoon 2020	Monsoon 2021				
	Unit	National	National	Hills	Dry	Delta	Coastal
Urea - kg	mean	38.0	32.9	34.2	31.2	35.0	27.1
	median	33.3	25.0	25.0	25.0	29.2	20.0
Ammonium sulphate - kg	mean	5.3	4.1	2.6	3.3	6.2	2.3
	median	0.0	0.0	0.0	0.0	0.0	0.0
Other fertilizer - kg (compound 15_15_15)	mean	9.7	8.8	12.6	9.5	7.0	3.0
	median	0.0	0.0	0.0	0.0	0.0	0.0
Other fertilizer - kg (other compound combined)	mean	11.3	8.9	11.1	10.3	7.0	5.9
	median	0.0	0.0	0.0	0.0	0.0	0.0
Other fertilizer - kg (T_super)	mean	0.7	3.9	6.6	1.9	2.9	7.6
	median	0.0	0.0	0.0	0.0	0.0	0.0
Other fertilizer - kg (Potash)	mean	3.6	0.8	1.7	0.3	0.7	0.4
	median	0.3	0.0	0.0	0.0	0.0	0.0
Total fertilizer - kg	mean	68.6	59.3	68.9	56.5	58.8	46.3
	median	53.1	50.0	50.0	48.0	50.0	31.6

Source: Authors' calculations based on MAPS

Figure 3: Fertilizer use on paddy rice, monsoon 2021



Source: Authors' calculations based on MAPS

The MAPS also captures the extent to which rice farmers relied on hired labor, draught animals, and mechanization during the monsoons of 2020 and 2021 (Table 7). We see surprisingly few differences over time and most rice farms relied on similar labor arrangements over the two seasons. During the monsoon of 2021, only 17 percent of the rice farmers relied exclusively on their own family labor and 83 percent used outside help. On top of their own household labor, 67 percent of rice farmers used solely hired labor, 8 percent used exchange labor, and 7 percent used a combination of hired and exchange labor. Substantial differences are noted over agro-ecological zones with 88 percent of rice farmers in the Dry Zone relying on outside help while the Hills and Mountains rely more on their own labor. However, outside help is still high, with 53 percent of famers relying on hired labor. In contrast with other zones, in the Hills we see relatively more reliance on exchange labor. In the Delta and Coastal areas, 75 percent of rice farms relied on hired labor.

Rice farmers in Myanmar rely heavily on mechanization for their rice farm activities. Draught animals have traditionally been very important in rice cultivation but were used only by 38 percent of rice farmers. Draught animals still are important in the Dry Zone where 70 percent of the rice farmers used them. Nationally, 86 percent of farmers used a tractor for plowing plots and 60 percent used combine-harvesters to harvest paddy. Combine-harvesters are relatively less used in the Hills and Mountains, likely due to the higher share of upland rice cultivation making it more difficult for combine-harvesters to move around there. Most rice farmers relied on mechanization service providers for plowing but it is noteworthy that 27 percent used their own tractor for plowing. Again, we see little changes over time, despite increases in prices of fuel for the running of tractors and in the charges by service providers for plowing as well as harvesting services (MAPSA 2021b).

Table 7: Labor use and mechanization in paddy rice cultivation

Use on largest rice plot	Unit	Monsoon 2020 National	Monsoon 2021 National	Hills	Dry	Delta	Coastal
Non-family labor							
Hired	%	65.8	67.3	53.0	66.6	75.6	75.2
Exchange	%	8.2	8.5	15.5	12.6	1.6	2.7
Both	%	7.0	7.1	11.2	8.3	3.3	6.4
No	%	19.0	17.1	20.3	12.5	19.5	15.7
Draught animals							
Hired	%	12.9	12.9	10.2	23.6	5.2	10.5
Own	%	23.3	23.0	11.7	43.9	12.3	16.6
Both	%	1.4	1.2	0.9	2.0	0.9	0.0
No	%	62.4	62.9	77.2	30.4	81.6	72.9
Tractor for plowing							
Hired	%	58.0	58.9	44.3	62.2	67.0	53.1
Own	%	24.6	24.0	37.1	15.7	22.6	25.6
Both	%	2.7	2.9	2.4	3.0	3.7	1.1
No	%	14.7	14.2	16.2	19.0	6.7	20.2
Combine-harvester							
Hired	%	57.2	57.0	29.6	53.8	78.3	57.1
Own	%	2.3	2.6	3.6	1.7	2.9	2.1
Both	%	0.3	0.3	0.5	0.0	0.2	0.9
No	%	40.2	40.1	66.3	44.5	18.6	39.9

Source: Authors' calculations based on MAPS

Finally, we assess overall (commercial) input expenditures on rice. Commercial input expenditures might give a good indication of the intensity of input use in rice production.[8] Table 8 shows that input expenditures per acre increased on average by 9.7 percent, and by 20.0 percent using the median, during the 2021 monsoon compared to the previous one. Despite the significant reduction in credit from the government, micro-finance institutions, and the private sector (MAPSA 2021d, 2022d) and the reductions in income (MAPSA 2022c), it seems that farmers were somehow able to still increase expenditures on their rice plots and (partially) compensate for the increased prices of most inputs. The highest input expenditures per acre were noted in the Hills and Mountains and the Dry Zone (Table 8 and Figure 4).

Table 8: Monetary input expenditures (MMK/acre) on paddy rice

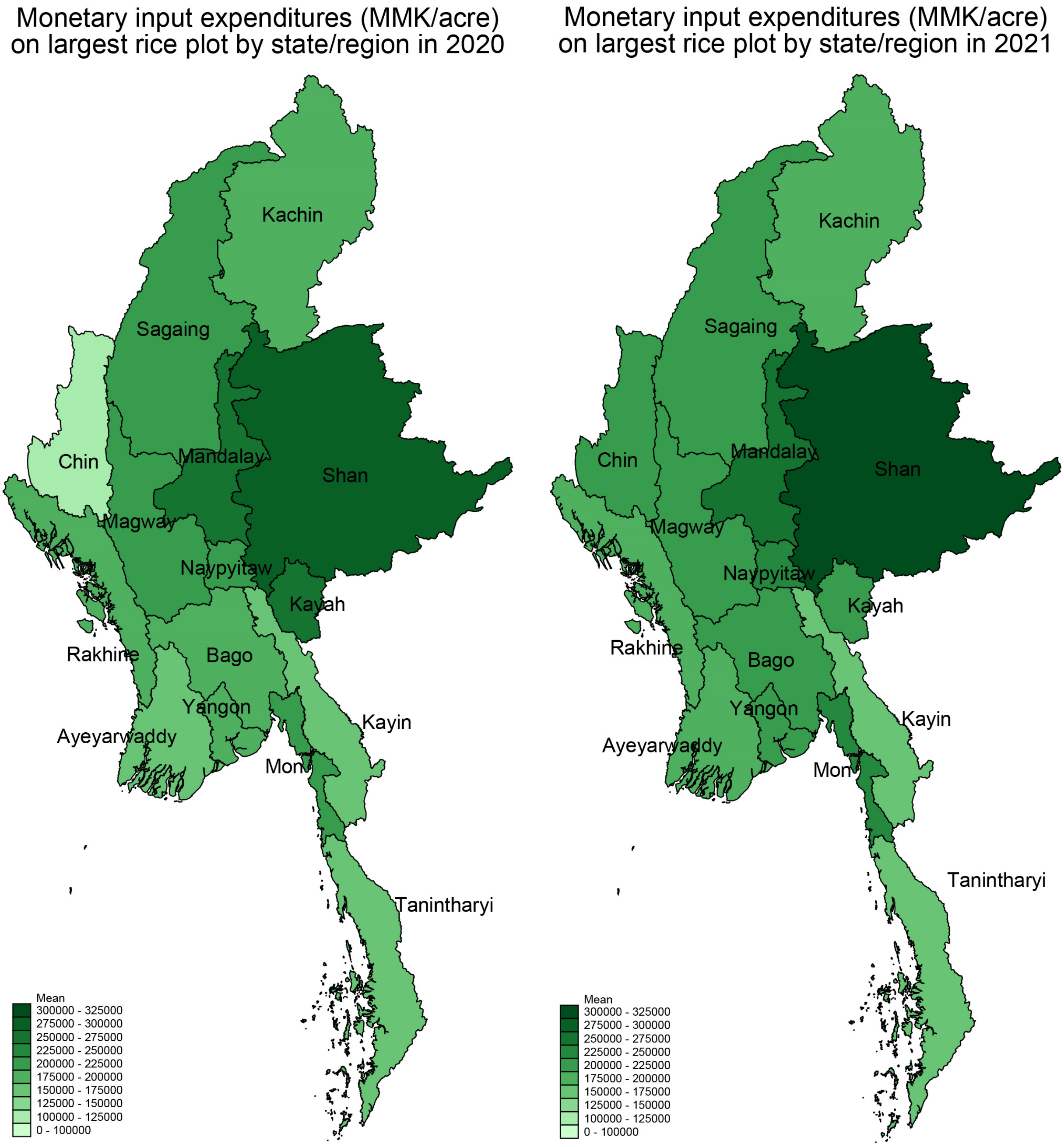
Use on largest rice plot	Monsoon 2020	Monsoon 2021				
	National	National	Hills	Dry	Delta	Coastal
Mean	203,505	223,297	265,329	229,646	199,650	185,695
Median	166,667	200,000	200,000	200,000	175,000	160,000

Source: Authors' calculations based on MAPS

Despite the problems with declining incomes overall, the problematic banking situation, and the reduced access to credit, we note relatively small changes in farm management practices, input use, and input expenditures over the last two seasons. Rice farmers were, on average, able to increase expenditures on rice production and were therefore able to maintain most agricultural input use at similar levels in the monsoon of 2021 as in the previous monsoon. The primary difference between the two years is a reduction of chemical fertilizer usage, by 14 percent.

[8] There are likely a number of issues with the measurement of input expenditures in MAPS. First, we only rely on monetary input expenditures. This is an imperfect way of assessing inputs into rice production as there are a number of non-monetary inputs going into rice production as well, such as family labor, organic fertilizer, and animal traction. Second, monetary input expenditures were approximated by farmers asking for a simple measure of what they spent on their largest rice plot. This might have been complicated to answer for farmers given that a number of inputs are bought in bulk and getting at the exact costs for a plot might therefore have been wrongly evaluated. Coming with a single number at once – combining all costs of fertilizer, agro-chemicals, mechanization, and hired labor – might also have been problematic. It is therefore likely that there is measurement error in this variable and a caveat for further analysis.

Figure 4: Input expenditures (MMK/acre) on paddy rice, monsoon 2020 and 2021



Source: Authors' calculations based on MAPS

5. NATURAL AND OTHER SHOCKS

Agriculture is a risky business. Climatic shocks are generally important risks in agricultural production.[9] When asked about the incidence of natural or other shocks, 30 and 31 percent of the rice farmers indicated that they were negatively impacted by at least one of these shocks in 2020 and 2021 respectively. However, the shocks reported over these two years were different. Drought negatively impacted 22 percent of (shock-affected) rice farmers in 2020 while only 16 percent were impacted in 2021. On the other hand, there were more complaints in 2021 of irregular rains (18 percent in 2021; 15 percent in 2020) and heavy rains (23 percent in 2021; 16 percent in 2020).

A variety of shocks have impacted agro-ecological zones and states/regions differently (Table 9). In the Dry Zone, 38 percent of (shock-affected) farmers were impacted by drought in 2020 and 26 percent during the monsoon season of 2021 (Figure 5). Floods are more frequently mentioned in Coastal areas (24 percent during the monsoon of 2020; 28 percent during the monsoon of 2021) (Figure 6). Pests and disease problems were mentioned by 48 percent of the (shock-affected) rice farmers in 2021, but these shocks were most often mentioned in the Delta region compared to other regions.

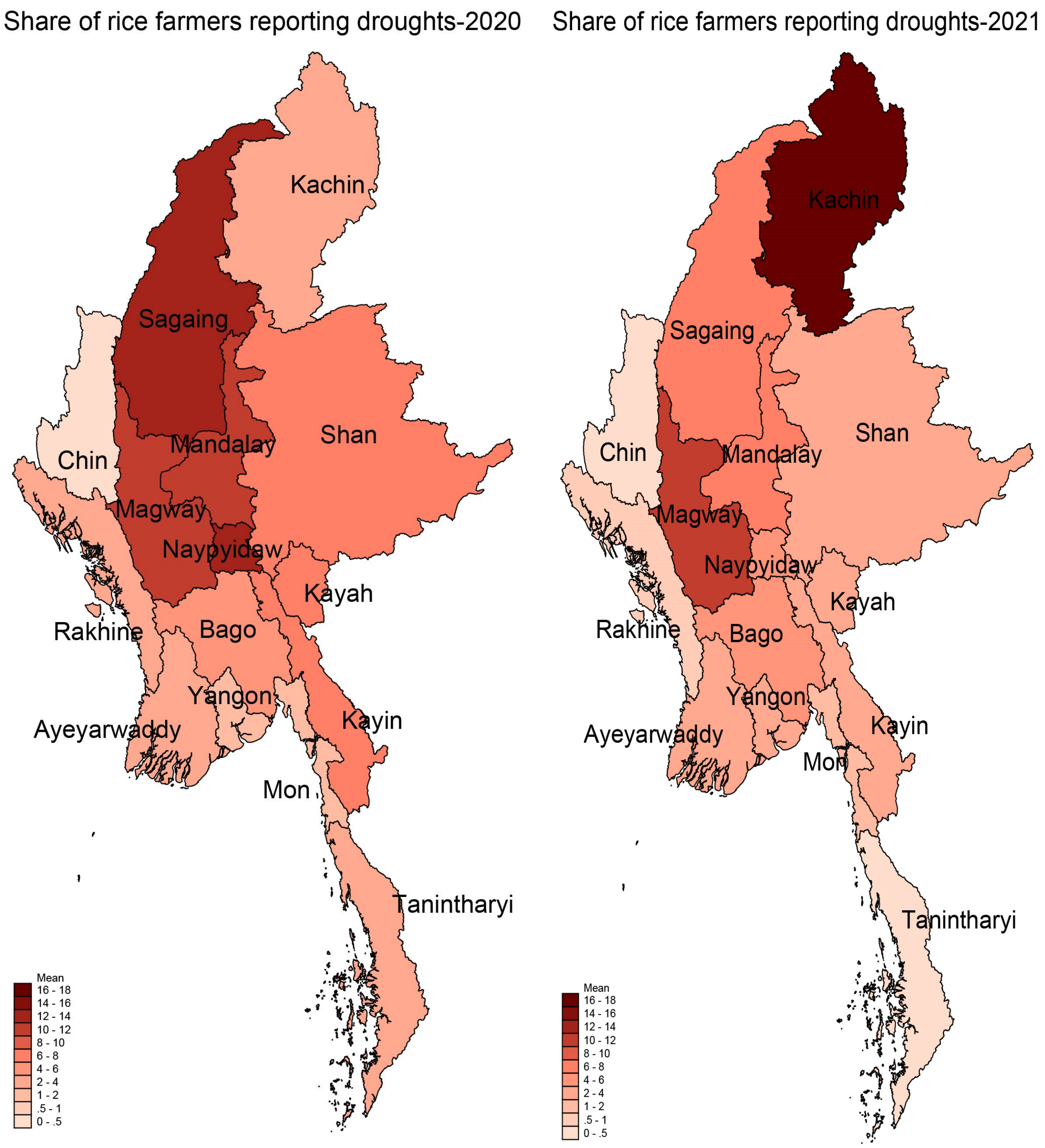
Table 9: Incidence of natural and other shocks

	Unit	National	Hills	Dry	Delta	Coastal
		Monsoon 2020				
Crop negatively affected by any shock	% yes	30.0	26.6	31.3	31.8	27.6
If yes, which one? (100% = all shock affected farmers)						
Drought	% yes	22.0	20.5	38.1	10.6	11.1
Poor access to irrigation water	% yes	3.5	6.0	4.9	1.5	-
Irregular rain	% yes	14.9	13.0	15.6	16.6	9.5
Heavy rains	% yes	16.0	12.5	11.4	20.2	24.4
Floods	% yes	14.9	15.7	12.4	14.7	24.4
Flash floods	% yes	2.0	1.7	1.0	2.6	4.6
Extreme temperature	% yes	2.0	4.1	1.3	1.3	2.4
Pest, diseases, weeds	% yes	49.7	50.8	38.7	59.2	49.6
Damage by animals	% yes	10.3	11.4	8.8	12.3	4.8
Others	% yes	1.6	1.5	1.8	1.5	1.0
		Monsoon 2021				
Crop negatively affected by any shock	% yes	31.0	30.1	27.6	36.5	25.1
If yes, which one? (100% = all shock affected farmers)						
Drought	% yes	16.3	18.2	26.5	10.1	3.0
Poor access to irrigation water	% yes	2.5	3.2	4.7	0.9	-
Irregular rain	% yes	18.4	15.7	18.5	21.0	10.9
Heavy rains	% yes	23.4	24.7	23.3	23.2	20.2
Floods	% yes	13.1	9.3	14.4	11.6	28.4
Flash floods	% yes	2.5	2.1	1.7	2.6	6.5
Extreme temperature	% yes	3.0	4.3	3.0	2.4	2.7
Pest, diseases, weeds	% yes	48.3	50.0	33.3	57.4	52.0
Damage by animals	% yes	11.5	11.9	7.2	14.9	9.0
Others	% yes	1.8	1.8	0.8	2.5	1.1

Source: Authors' calculations based on MAPS

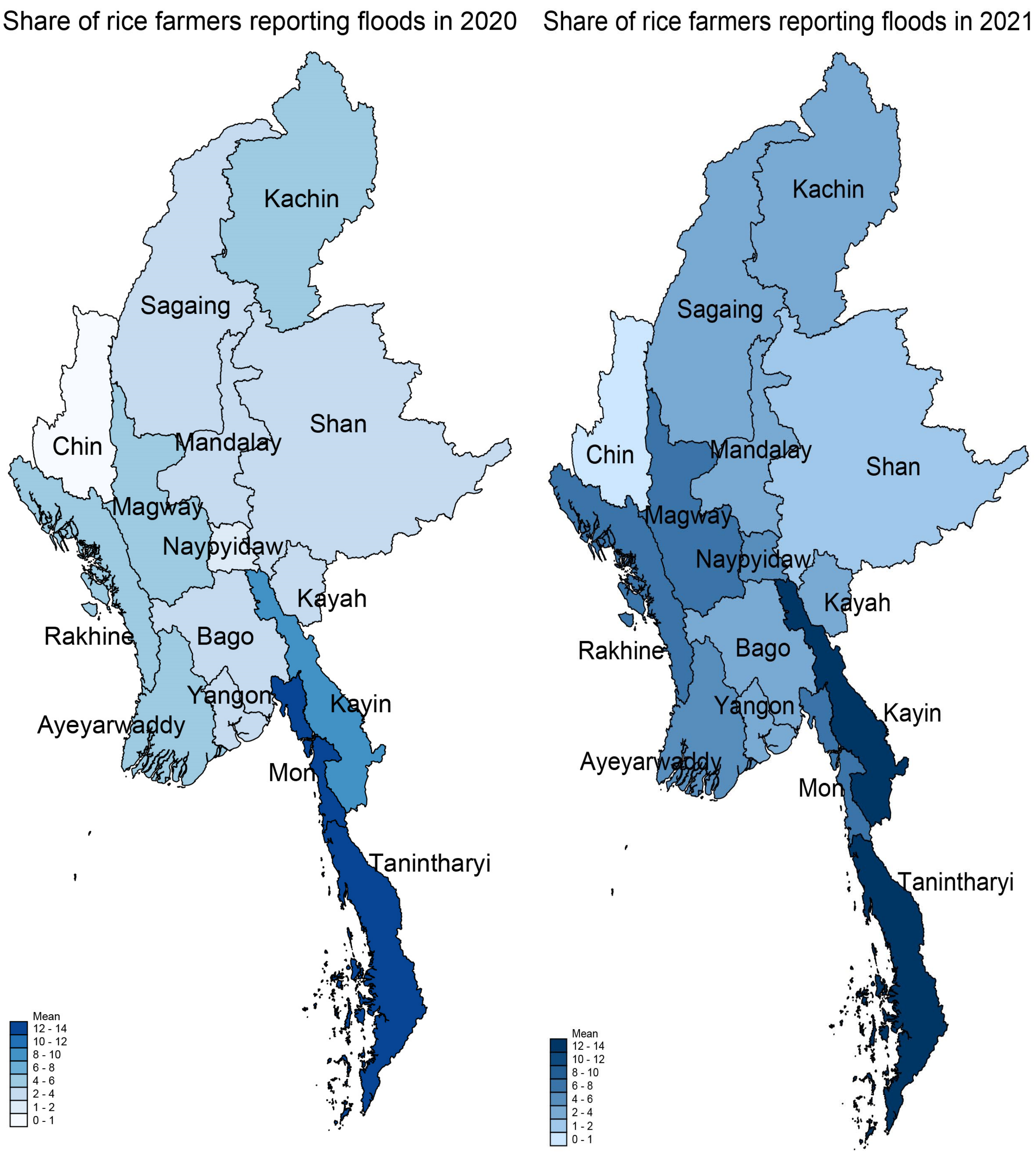
[9] It is expected that such climatic shocks will increase in the future. Myanmar is seen as one of the countries most affected by climate change globally (IFRC 2021).

Figure 5: Incidences of drought for paddy rice farmers, monsoon 2020 and 2021



Source: Authors’ calculations based on MAPS

Figure 6: Incidences of floods for paddy rice farmers, monsoon 2020 and 2021



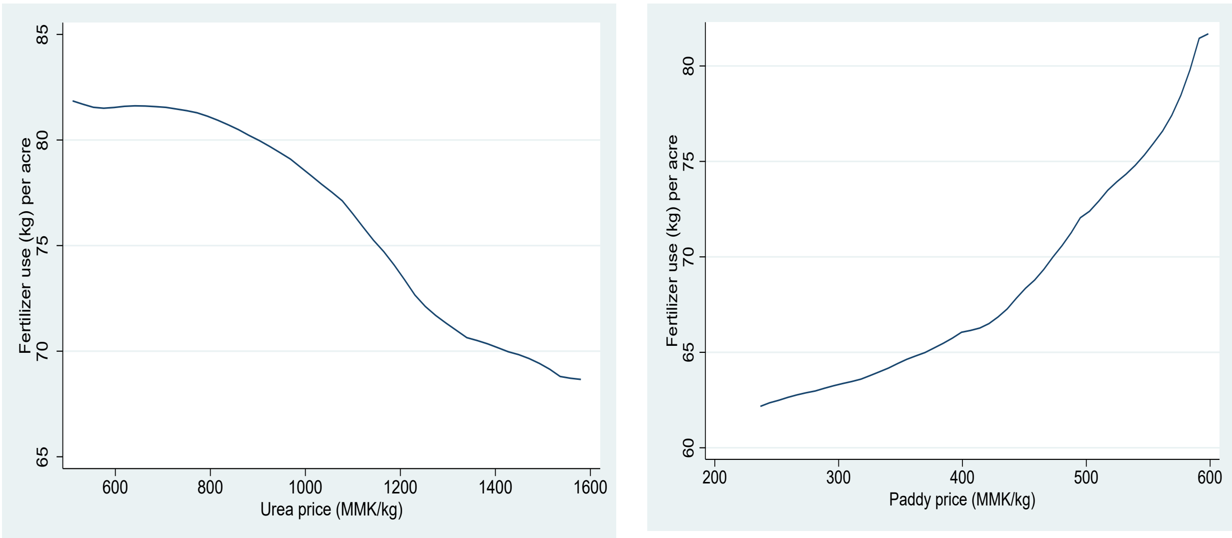
Source: Authors' calculations based on MAPS

6. THE ROLE OF CHEMICAL FERTILIZER ON RICE PRODUCTIVITY

Agricultural input use and farm management practices changed little between the monsoon of 2020 and 2021 except for reduced fertilizer use. We therefore focus on fertilizer's role in rice productivity, but also look at commercial expenditures more broadly. The variations of fertilizer use over plots and years allow us to assess factors affecting fertilizer adoption, the influence of price changes, and the returns to fertilizer use over these two seasons (see Annex 1). Given large fertilizer price increases, we want to understand to what extent fertilizer and rice price changes explain adoption and use rates, on top of other factors.

We expect price incentives to play a major role in fertilizer use, which is an important consideration in Myanmar where there is significant price variation due to market access and volatility over time (see Annex 1). Using simple two-way graphs, we illustrate how a change of the urea price from 800 to 1600 MMK/kg is linked to reduced fertilizer use from 82 kgs to 68 kgs per acre (Figure 7). On the other hand, farmers that receive higher rice prices use chemical fertilizers more intensively. An increase of the rice price from 300 to 600 MMK/kg is associated with an increase of chemical fertilizer use by 18 kgs per acre (from 63 kgs per acre to 81 kgs per acre).[10]

Figure 7: The relationship of chemical fertilizer use and paddy rice and fertilizer prices[11]



Source: Authors' calculations based on MAPS

Fertilizer use is strongly linked to rice yields (Figure 8).[12, 13] However, we note diminishing marginal returns when more than 150 kgs of fertilizer per acre is used. The graphs show that at average fertilizer use (69 kgs per acre in 2020 and 59 kgs in 2021), 1 kg of fertilizer generates between 4 and 5 kgs of extra paddy rice for all types of fertilizers. The figure (bottom, right) also illustrates the strong positive linkages between total commercial input expenditures (incl. fertilizer, mechanization, labor use, etc.) and rice yields.

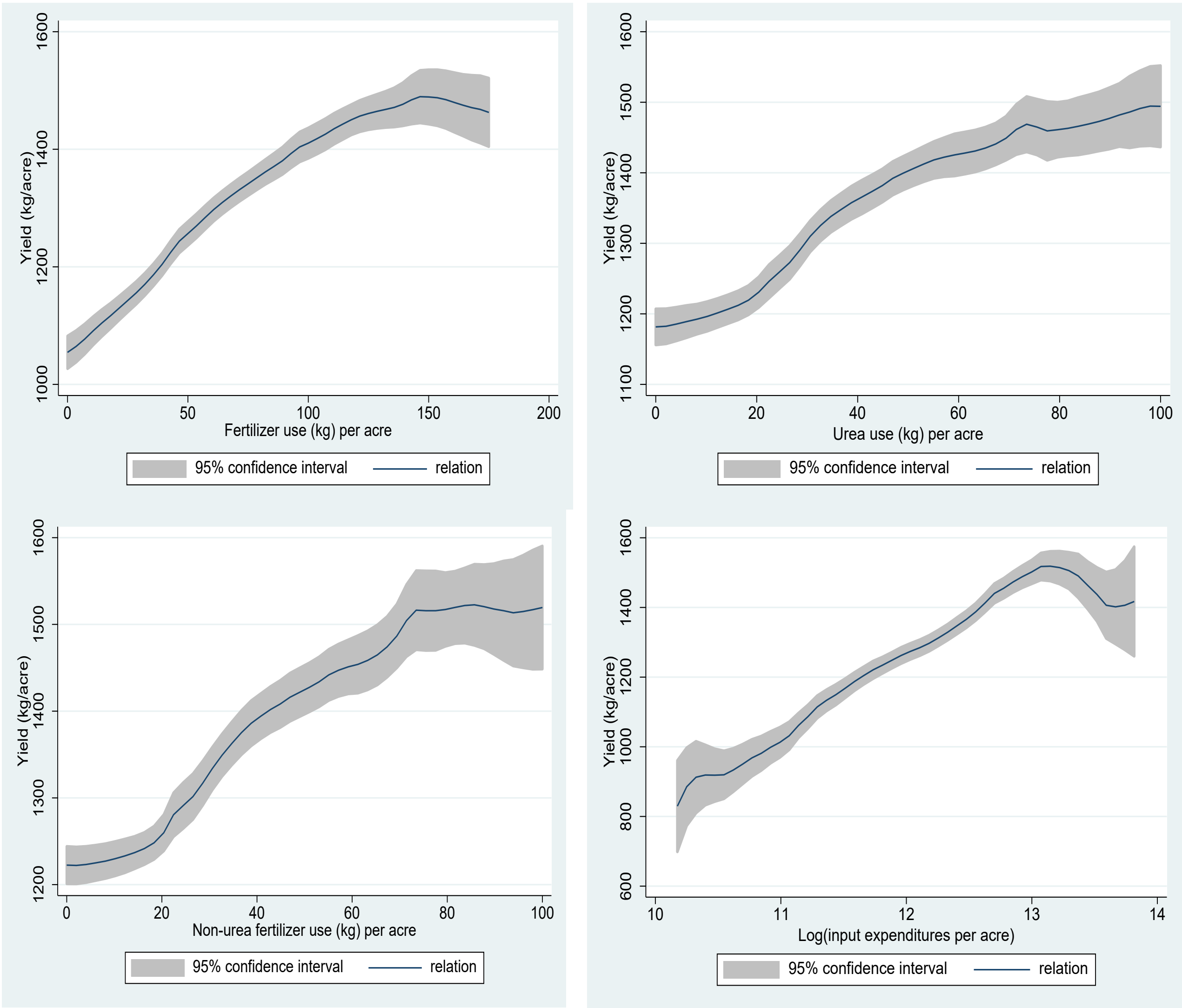
[10] For a more detailed assessment of associates of fertilizer use, see Annex 2.

[11] Own prices, as reported by farmers themselves.

[12] We exclude approximately 5 percent of the highest users of urea and non-urea fertilizers, as there might have been measurement error for those.

[13] This is line with a survey of rice producers in Myanmar (World Bank 2016). They find that an increase in fertilizer use from low to medium use (by 107 kgs per hectare) increases productivity by 360 kgs/ha, an return of 3.64 kgs per kg of fertilizer.

Figure 8: Fertilizer use and commercial input expenditures on paddy rice yields, monsoon 2020 and 2021 data combined



Source: Authors' calculations based on MAPS

The returns to fertilizer use can differ because of agro-ecological conditions, shocks during the growing season, upland or lowland growing conditions, assets owned by farmers, and other factors. To assess returns when we control for a number of these different factors, we rely on a multivariate regression analysis. To allow for curvature in the returns to fertilizer use, as suggested in the exploratory graphs above, we specify a quadratic relationship by using quantities and squared quantities of chemical fertilizer use in the model. Different specifications are presented in Table 10.

In the parsimonious model where we only control for agro-ecological zones, the returns to 1 kg of fertilizer are 4.3 kgs of paddy rice at low levels of use. Due to a significant negative quadratic term, marginal returns decrease with increasing use, becoming zero at 244 kgs of fertilizer applied. Returns to fertilizers for an average rice plot during the monsoons of 2020 and 2021 (69 and 59 kgs of fertilizer use per acre respectively) would be 3.1 and 3.3 kgs respectively. Returns are slightly lower when we control for township dummies instead of agro-ecological zones only (model 2). Returns to urea and non-urea fertilizers are similar but are a bit lower than when we use overall fertilizer use (model 3). When we control for other inputs in the longer specification, the estimates of these returns decrease and overall returns at low levels of use are 3.6 kgs of paddy rice (model 4).

Other explanatory variables of rice yields show expected associations. Upland fields and fields where seeds are broadcast instead of row-planted or transplanted and where Meedon/Pawsan seeds were used show lower yields. Plots where organic fertilizer, lime, and pesticides are used have higher yields. Higher levels of mechanization and less hired labor use are associated with lower rice yields. Controlling for inputs and shocks, yields in the monsoon of 2021 were not significantly different from those in 2020, indicating that the variables used in the model mostly explain the differences. Droughts especially had a significant negative effect on yields. No difference in the effect is however seen between the years even though more farmers were affected by droughts during the monsoon of 2020 and productivity was therefore more affected.

In a final fifth model, we look at how total commercial expenditures affect rice yields, ceteris paribus. We find strong and significant effects, with a doubling of input expenditures leading to an increase of rice yields by 210 kgs per acre, indicating the importance of market orientation for higher paddy yields.

Table 10: Associates of paddy rice yields (kgs per acre), monsoon 2020 and 2021

Variable	Unit	Model 1		Model 2		Model 3		Model 4		Model 5	
		Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
Fertilizer use											
Quantity	kg	4.34	11.71	4.13	11.86			3.61	10.07		
Quantity squared	kg	-0.01	-4.77	-0.01	-4.82			-0.01	-4.05		
Urea	kg					3.87	6.71				
Urea squared	kg					-0.01	-1.71				
Non-urea	kg					3.73	7.35				
Non-urea squared	kg					-0.01	-2.99				
Other inputs											
Purchased seeds	1=yes							89.87	5.37		
Seed variety (default = Emata)											
Letywesin	1=yes							43.01	2.44		
Meedon/Pawsan	1=yes							-190.92	-9.90		
Other	1=yes							7.77	0.18		
Upland field	1=yes							-196.82	-5.71	-274.00	-7.89
Broadcast	1=yes							-46.75	-2.86		
Organic fertilizer used	1=yes							47.40	3.22		
Lime used	1=yes							35.77	1.57		
Pesticides used	1=yes							22.54	1.49		
Mechanization used	1=yes							115.30	3.90		
No hired labor used	1=yes							-18.39	-0.89		
Working hh members	number							-3.36	-0.54	0.68	0.11
Total input expenditures											
Commercial inputs	log(MMK/acre)										
Other controls										210.11	17.16
Agro-ecological zone (Delta = default)											
Dry Zone	1=yes	177.17	11.17			180.73	11.31	153.27	8.49	173.97	10.38
Coastal Area	1=yes	31.13	1.03			32.68	1.09	148.83	4.84	66.12	2.13
Hills and Mountains	1=yes	-54.42	-2.39			-56.86	-2.50	-31.94	-1.19	1.96	0.08
Time (default = year 2020)											
Year 2021	1=yes							13.47	0.89	-45.42	-2.90
Shocks (default = no shocks)											
Drought	1=yes							-196.16	-5.16	-180.31	-4.70
Drought * year 2021	1=yes							57.26	0.95	49.98	0.81
Flood	1=yes							-61.49	-1.33	-84.56	-1.67
Flood * year 2021	1=yes							-97.54	-1.47	-60.56	-0.85
Farm asset dummies	1=yes	no		no		no		yes		yes	
Township dummies	1=yes	no		yes		no		no		no	
Constant		1044.23	63.14	683.60	8.17	1060.48	66.89	978.17	19.04	-1182.41	-7.79
Number of observations		5,262		5262		5,262		5,262		5,063	
R2		0.10		0.27		0.10		0.16		0.13	

Source: Authors’ calculations based on MAPS, robust standard errors

7. RICE PRODUCTIVITY DURING THE MONSOON OF 2020 AND 2021

National yields averaged 1,289 kgs per acre (the median was 1,254 kgs per acre) or 3.1 tons per hectare for the monsoon of 2021 (Table 11). These estimates are similar to the USDA estimate of 2.8 tons per hectare for 2021 (USDA 2022). However, they are significantly lower than MoALI's estimated average yields in 2021 of 3.7 tons per hectare.[14]

A comparison by state (Figure 10 and Table 11) shows that average yields in 2021 were generally highest in the Dry Zone (Mandalay (1,450 kgs/acre), Magway (1,503 kgs/acre) and Sagaing (1,406 kgs/acre)) and lowest in Chin (845 kgs/acre), Kayah (1,014 kgs/acre), and Tanintharyi (1,060 kgs/acre). No substantial changes are observed between 2020 and 2021. The mean declined by 1.5 percent while the median did not decline compared to the previous season.[15] While most states and regions showed stable yields, some areas have performed poorly. Rice yields substantially declined in Kayah and Chin, the two regions that have also shown the highest levels of food insecurity in recent assessments, due to higher levels of unrest and conflicts (MAPSA 2022c).

Table 11: Paddy rice yields on the largest plot (kgs/acre), monsoon 2020 and 2021

	2020		2021	
	Mean	Median	Mean	Median
Kachin	1,496	1,568	1,319	1,254
Kayah	1,092	948	1,014	941
Kayin	1,232	1,254	1,264	1,254
Chin	988	896	845	980
Sagaing	1,404	1,393	1,406	1,393
Tanintharyi	1,129	1,150	1,060	1,045
Bago	1,401	1,393	1,343	1,359
Magway	1,470	1,463	1,503	1,463
Mandalay	1,465	1,463	1,450	1,463
Mon	1,106	1,045	1,212	1,150
Rakhine	1,251	1,115	1,275	1,189
Yangon	1,198	1,115	1,172	1,069
Shan	1,172	1,045	1,165	1,045
Ayeyawady	1,201	1,045	1,142	1,045
Nay Pyi Taw	1,355	1,463	1,408	1,393
Hills	1,216	1,170	1,187	1,087
Dry	1,429	1,418	1,438	1,463
Delta	1,277	1,254	1,232	1,229
Coastal	1,224	1,115	1,229	1,176
Total	1,308	1,254	1,289	1,254

Source: Authors' calculations based on MAPS

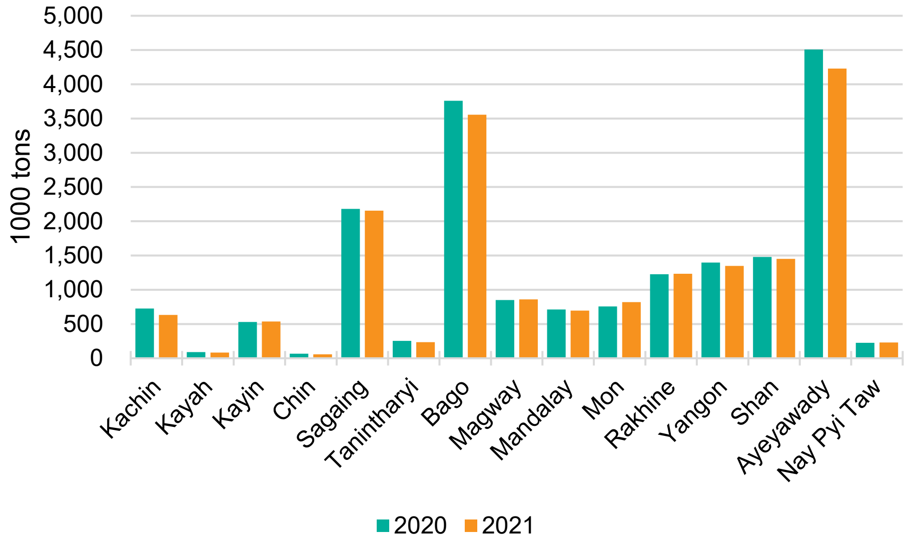
We do not have good data on changes in rice area cultivated during the monsoon of 2021 per state or region and therefore rely on assumptions to make national estimates of rice productivity and production. First, using the average yield of the largest plot of the farmers interviewed as an indication of the average yield for each state/region, we estimate a reduction of total rice productivity (yields) of cultivated rice areas by 2.1 percent. Second, in MAPS, active rice farmers in 2021 reported

[14] Dorosh et al. (2019) showed similar differences between MoALI and USDA estimates before.

[15] USDA (2022) showed a decline in yields by 4 percent.

a rice area reduction by 0.6 percent between the monsoon of 2021 and 2020 (from 5.33 to 5.30 acres). Third, we make assumptions of previous area allocation of households that migrated over the last year prior to the MHWS.[16] We estimate that this reduced the rice area by a further 0.7 percent. Assuming similar declines in rice area for all states and regions (Figure 9), this suggests that rice production at the national level would have decreased by 3.4 percent. However, as we lack good data on yields on all rice plots and on areas cultivated at state and regional level[17], more research is needed to better assess area cultivated and national paddy rice production levels.

Figure 9: Paddy rice production during the monsoon of 2021



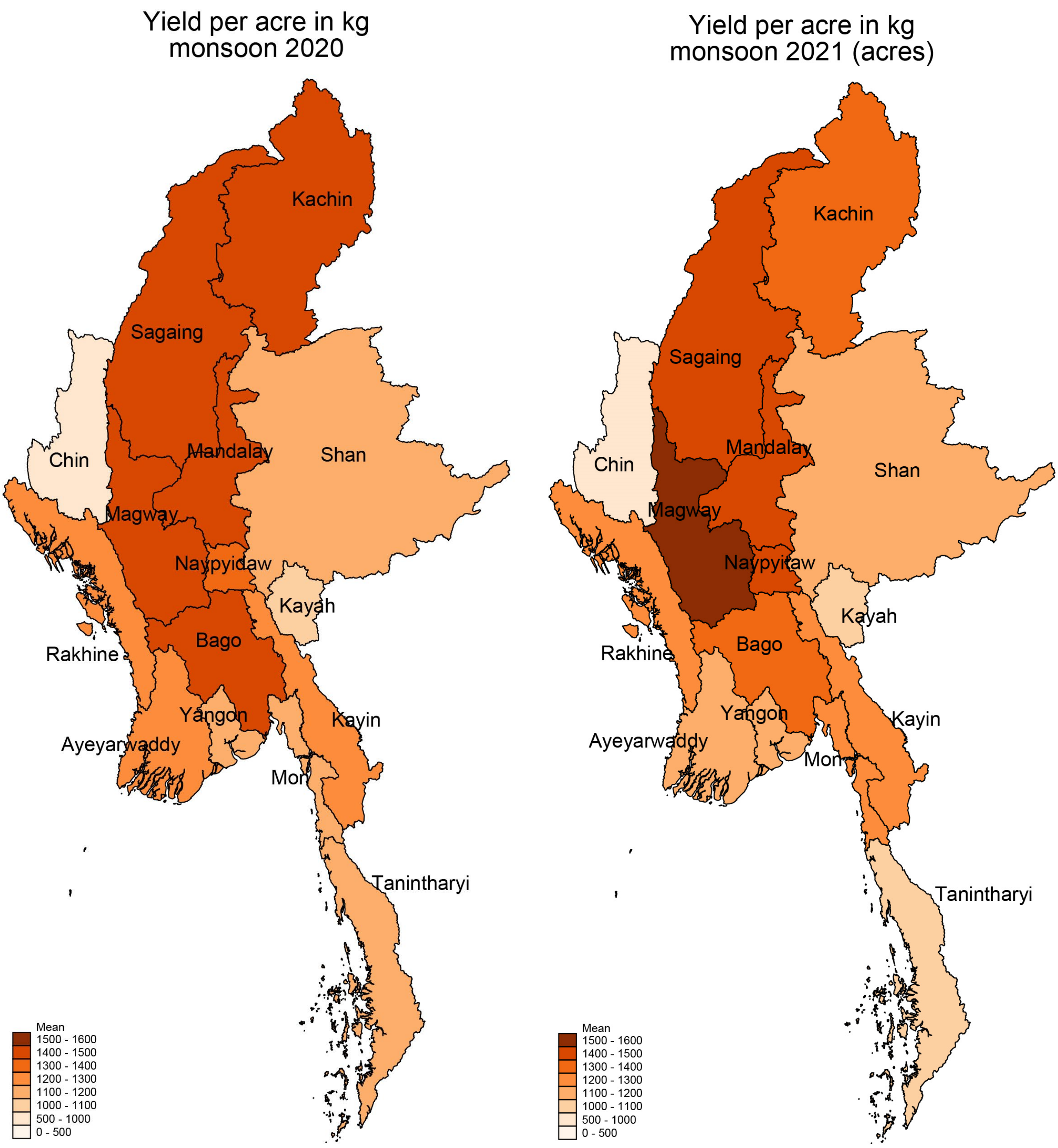
Source: Authors' calculations based on MAPS

A number of results of alternative datasets and studies seem to confirm the relatively small declines in rice production in the country: (1) A crop trader survey conducted in March indicated that rice trade was at higher levels in March 2021 than a year earlier (MAPSA 2022d); (2) A survey with rice millers conducted in February – March 2022 shows that the estimated harvest by mills declined by 15 percent compared to a year earlier (MAPSA 2022e), possibly because of farmers withholding more rice for their own consumption and delivering less to mills. However, the median turnover did not change; (3) Mechanization providers during a survey in January 2022 reported that they provided harvesting services during the monsoon of 2021 on areas comparable to the same time in 2020, although at higher costs (MAPSA 2022f); (4) USDA (2022) reports a decline in rice production overall by 2 percent compared to the 2020/21 year; (5) Exports of rice in 2021 (1,901,426 tons) were 18 percent lower in 2021 than in 2020 but exports in the first three months of 2022 (likely reflecting monsoon 2021 production) were 243,752 tons higher than a year earlier (USDA 2022).

[16] During the 12 months prior to the MHWS, 2.8 percent of households migrated at the national level (59 percent of them living in urban areas and 41 percent in rural areas). Based on the MHWS, we estimate that 8 percent and 52 percent of households in urban and rural areas are typically crop farmers. We assume that migrant crop farmers were 'average' farmers in 2020 and then abandoned all their cropland in 2021. This would lead to a reduction in the number of farmers and paddy area cultivated by 0.73 percent (=2.81*(0.59*0.08+0.41*0.52)).

[17] We only interviewed crop farmers that cultivated crops during the monsoon of 2021. Farmers that cultivated crops during the monsoon of 2020, but not during the monsoon of 2021, were not part of the sample. Farmers that migrated to other areas were therefore missed.

Figure 10: Paddy rice yields, 2020 and 2021



Source: Authors' calculations based on MAPS

8. CONCLUSIONS AND IMPLICATIONS

We rely on rice input and productivity data for the monsoon seasons of 2020 and 2021 from the Myanmar Agriculture Performance Survey (MAPS). The survey covers plots of 2,672 rice producers, spread over 259 townships in all states/regions of the country. We find that:

1. Rice productivity at the national level during the monsoon of 2021 decreased on average by 2.1 percent compared to the monsoon of 2020. Considering area reductions, it is estimated that national paddy production decreased by 3.4 percent compared to the monsoon of 2020.
2. Some areas performed substantially worse. Rice yields were low and declined significantly in Kayah and Chin, two conflict-affected states that have shown the highest levels of food insecurity in recent assessments.
3. Prices for most inputs used in rice cultivation increased significantly between these two seasons. Prices of urea, the most important chemical fertilizer used by rice farmers, increased by 56 percent on average and mechanization costs increased by 19 percent.
4. Rice farmers adjusted to higher input prices by increasing their input expenditures (by 10 on average and 20 percent for the median) but the increased expenditures did not compensate for the price increases of chemical fertilizer.
5. Fertilizer use on major rice plots declined by 14 percent on average in 2021 compared to the year before. As fertilizer use and returns are lower during the monsoon compared to other seasons, the implications of these reductions on rice yields were minor.
6. Rice farmers suffered less from weather shocks during the monsoon of 2021 than during the monsoon of 2020, when a larger number of farmers, especially in the Dry Zone, were hit by severe droughts.
7. Paddy prices at the farm increased by 8 percent, significantly less than input prices, squeezing rice farmers' profits during the monsoon of 2021.

Despite worries that the rice production system would not hold up well given limited access to credit, higher input costs, mobility problems, increased transportation costs, insecurity issues, and marketing problems, it seems that rice production during the monsoon of 2021 has weathered the storm well and that declines in rice output have been limited. The rice sector has been resilient assuring livelihoods for farmers as well as rice availability. The rice sector has therefore shown more stability than other parts of Myanmar's economy (World Bank 2022). There are however many concerns that might limit the rice sector's role as a shock absorber in the future.

First, the summer rice crop that is harvested between monsoon crops in some areas was estimated to make up 17 percent of annual rice production in 2020/21.[18] Farmers normally use more fertilizer during non-monsoon crops as returns to fertilizer use are typically larger given more controlled – often irrigated – production environments (Singh et al. 2017; World Bank 2017). The summer crop is also more reliant on electricity/fuel investments (for irrigation) than the monsoon crop. Given recent problems with fertilizer, fuel, and electricity access, rice output during the summer season may be more compromised than during the recent monsoon.

Second, it is expected that fertilizer prices for the upcoming monsoon season will increase further to almost triple compared to two years earlier because of the war in Ukraine. To understand how the profitability of fertilizer use in rice production will change, we compare price ratios of paddy and urea with a "break-even" situation, relying on the results reported in Table 11.[19] This break-even situation

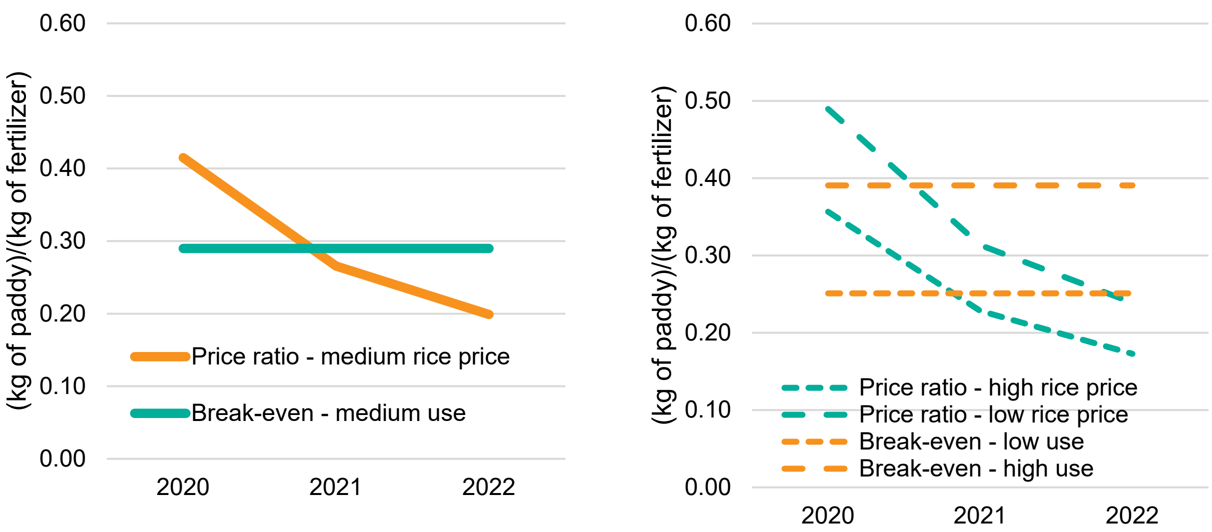
[18] MoALI data.

[19] For the calculation of the break-even ratio (0.24 kgs of fertilizer needed to obtain 1 kg of paddy), we rely on the medium quantity of fertilizer used per acre over the last two years (50 kgs) and use the results of model 1 in Table 11.

reflects a case where fertilizer use becomes unprofitable. We use the 25th (low price), 50th (medium price), and 75th (high price) percentile of paddy prices reported after the 2020 and 2021 monsoon harvest and divide those by the average urea prices of the subsequent monsoon season, assuming that farmers will use proceeds of rice and paddy sales to pay for fertilizers the season after.[20]

Considering the medium price situation, farmers in 2020 could afford 1 kg of urea when they sold 2.4 kgs of rice (Figure 11). In 2021, 3.8 kgs of rice were required. This was still just around the profitability breakeven point (for medium users, i.e. 50 kgs per acre). However, with the expected increases in fertilizer prices in the next months, 5 kgs of rice are required to pay for 1 kg of urea, making fertilizer use in the medium scenario unprofitable.[21] While the average farmer next year is below the breakeven point, some farmers may be able to benefit from higher paddy prices to justify investing in fertilizers (Figure 11, right). Rice prices are currently increasing (MAPSA 2022d), improving this ratio, but it is unclear how much they will increase and what farmers' price expectations are for the future as this is what ultimately determines their decisions to purchase fertilizer. Moreover, previous research (Morris et al. 2007) has shown that farmers usually require a buffer above the break-even point before they are willing to invest in fertilizers which does not bode well for fertilizer use during the next monsoon season.

Figure 11: Profitability of fertilizer use (urea) on monsoon paddy rice, 2020 – 2022



Source: Authors' calculations based on MAPS

Third, future investments will be problematic for most rice farmers given the number of coping strategies they have used over the last two years as there is a limit to how long and how often some of these coping mechanisms can be applied. Rice farmers were asked in January what type of coping strategies they had used to deal with a lack of food or money in the 30 days before the survey. Table 12 shows that 58 percent of the farmers used their savings and 40 percent borrowed money. Farmers of different farm sizes employed these strategies, but borrowing was done more by the biggest farmers, possibly because they had to make the largest investments in future rice production. While 18 percent of the rice farmers mortgaged household assets, this again was relatively more common among the larger farmers (36 percent). Reducing input expenditures in preparation for the summer crop and potentially the next monsoon season was also mentioned by 57 percent of rice farmers, confirming concerns for future harvests.

[20] As paddy prices of the monsoon of 2020 changed little compared to the year before (Goeb et al. 2021), we use the price distribution of the year before as an approximation.

[21] Urea prices are expected to be sold at 90,000 MMK per bag of 50 kgs (personal communication, fertilizer distributor).

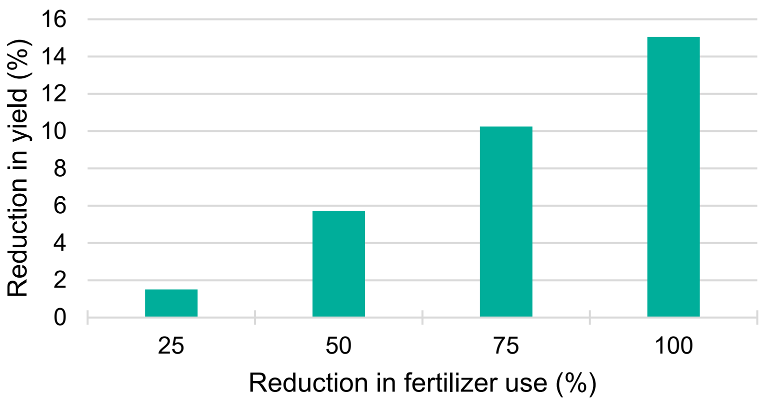
Table 12: Coping mechanisms used by rice farmers

	Unit	Farm size					
		0-<2 acres	2-<5 acres	5-<8 acres	>=8 acres	# of rice farmers	All
Spent saving	%	55.7	59.8	48.8	50.7	1543	57.7
Borrowed money	%	44.3	48.6	32.4	60.3	1072	40.1
Sold household assets / goods (radio, furniture, television, jewelry, etc.)	%	10.8	9.9	2.5	8.3	252	9.4
Mortgaged household assets / goods (radio, furniture, television, jewelry, etc.)	%	18.4	23.6	16.7	36.3	483	18.1
Sold or consumed seed stocks (ag HH only)	%	22.0	19.2	19.1	9.8	556	20.8
Reduced agri-input expense (ag HH only)	%	58.4	55.9	38.6	55.9	1528	57.2
Mortgaged land	%	0.5	0.6	0.0	0.0	13	0.5
Mortgaged house	%	0.4	1.0	0.0	0.0	14	0.5
Sold agri productive assets (ag HH only)	%	5.3	4.0	3.0	0.0	133	5.0

Source: Authors' calculations based on MHWS

Fourth, while fertilizers are a priority import into Myanmar, new rules establishing a fixed exchange rate that is lower than the market rate as well as a requirement that foreign currency be converted into local currency in a short time span, make it more complicated to import fertilizer into the country. Overseas suppliers fear that they will not receive appropriate payments.[22] Rice exporters face an implicit export tax by being required to use the official exchange rate, pushing down local rice prices. This policy change will therefore negatively influence the availability of chemical fertilizer in the country as well as input and output prices for rice farmers, reducing profitability and incentives for production. Fertilizer use will therefore be lower than during the monsoon of 2021. It is estimated that a reduction in fertilizer use by 25, 50, and 75 percent would lead to a reduction in paddy rice yields of 2, 6, and 10 percent respectively (Figure 12).

Figure 12: Simulations of reduction in paddy rice yields – comparing the monsoon of 2022 to 2021 – for different reductions of chemical fertilizer use



Source: Authors' calculations

In sum, the likelihood of reduced summer rice crop production, reduced ability of rice farmers to utilize coping strategies, declining incentives for rice cultivation and fertilizer use, and recent government currency policies suggest that more profound effects will be felt on rice production during the next agricultural season than have been seen during the monsoon of 2021.

[22] https://www.frontiermyanmar.net/en/rice-exports-dry-up-due-to-forex-restrictions-rising-prices/

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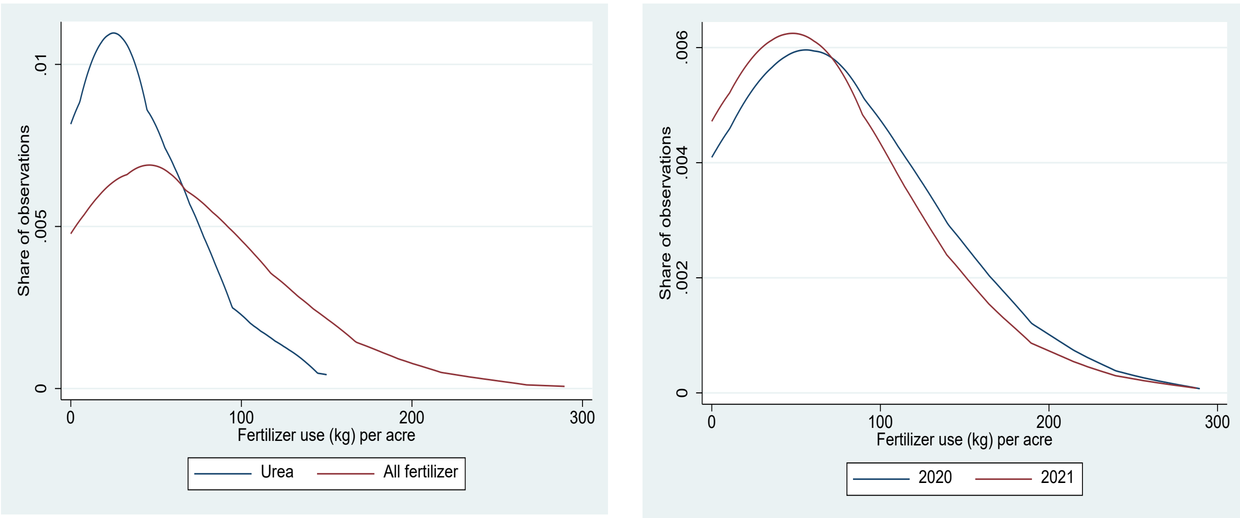
ANNEX 1: DISTRIBUTION OF FERTILIZER USE AND PRICES

Figure A.1 shows the distribution of urea and total fertilizer use per acre over the two monsoon seasons. No urea was used on 25 percent of the plots. When urea was used, rice farmers used 48 kgs per acre on average. However, there is significant variability. Approximately 30 percent of users used 25 kgs or less, 71 percent used 50 kgs or less, and only 29 percent used more than 50 kgs per acre. In the case of fertilizer use overall, 9 percent of the plots did not use any fertilizer. Overall, users applied 71 kgs per acre. Approximately 22 percent of uses applied 25 kgs or less, 44 percent 50 kgs or less, and 78 percent 100 kgs or less. The figure on the right illustrates the slight decline in fertilizer use between the two years.

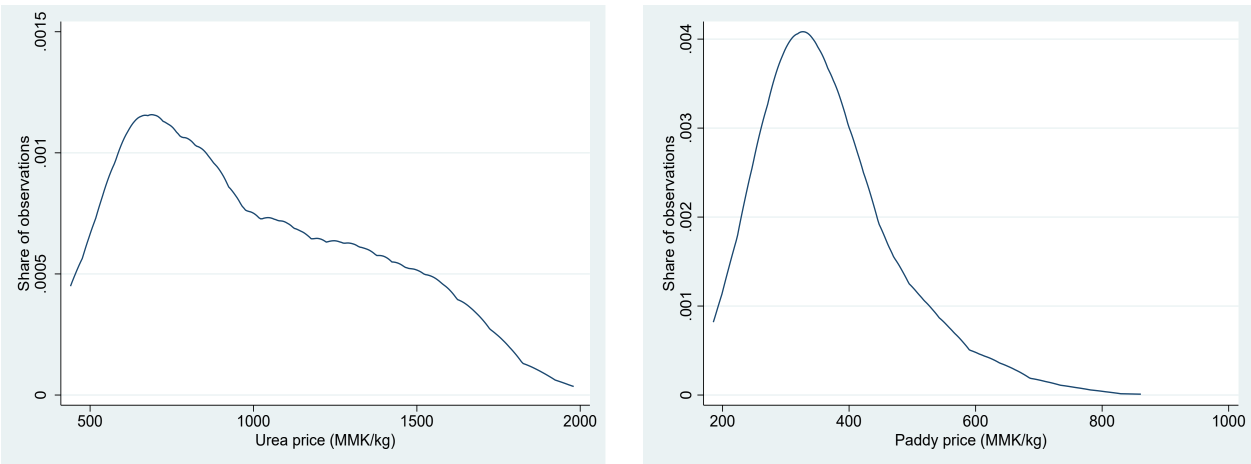
Figure A.1: Density distribution fertilizer use (kg/acre)



Source: Authors' calculations based on MAPS

The variation for rice prices as well as fertilizer prices is shown in Figure A.2. The graphs show the large variation of these prices over space and during these two monsoon seasons.

Figure A.2: Density distribution of prices of rice and urea as reported by rice farmers, monsoon 2020 and 2021



Source: Authors' calculations based on MAPS

ANNEX 2: ASSOCIATES OF FERTILIZER USE

Using multivariate analysis, we assess how fertilizer and rice prices, controlling for other confounding factors, are linked to the adoption of fertilizers over the last two monsoons (Table A.1). To do so, we estimate a linear double-hurdle model (Cragg 1971). In such a set-up, the "first hurdle" estimates the factors which determine whether chemical fertilizers are used on a particular plot, while the "second hurdle" estimates the determinants of the quantities of modern inputs used conditional on being used. Ricker-Gilbert et al. (2011) argue that this is often the most appropriate way to model modern input use in these settings, given the substantial number of farmers that do not use modern inputs, and consequently given the importance of modeling corner solutions correctly in such situations.

The quantity of fertilizer used per acre on the largest rice plot is used as the dependent variable. We present results from a parsimonious model and a more complete model. On the right side, the more complete model indicators reflect household characteristics, incentives (prices at the village or township level and market access), agro-ecological conditions, and a yearly dummy. In the parsimonious model, we drop the household characteristics and other incentives, except input and output prices. To illustrate the magnitude of these effects, we report average marginal effects which reflect the total marginal impacts on modern input use including both the first and second hurdles. A number of relevant findings stand out.

First, incentives matter significantly for adoption. A doubling of rice prices increases fertilizer use by 20 kg per acre in the parsimonious model – a 37 percentage increase over average use– and by 15 kg per acre when additional factors are controlled for. On the other hand, a doubling of fertilizer prices reduces their use by 13 kg per acre in the parsimonious model but has no significant effect at conventional statistical levels in the more complete model. Price sensitivity of fertilizer use is relatively low, indicating the necessity that farmers attach to using chemical fertilizer.[23] The results further show that market access measures are significant as well, on top of prices. Households far away from township centers or far away from bigger cities (of a population of over 50,000 people) use significantly less fertilizer than those with better market access.

Second, some household characteristics are not significantly related to fertilizer adoption. Gender and age of the farm management decision maker are not significant associates of fertilizer use. On the other hand, more educated farmers (beyond standard grades) and households with more working members in the household use more fertilizers, possibly because they are willing and able to work their land more intensively. We also see no effect of the size of the farm on intensity of fertilizer use.

Third, a significant drop in the use of fertilizer is seen during the monsoon of 2021 that is not explained by price changes and these other variables. This might be linked to other factors not modeled, such as reduced access to credit, income reductions, and an uncertain market prospect. We also see slight differences between agro-ecological zones in the use of fertilizer, with significantly less fertilizer being used in coastal zones compared to the rest of the country, all other things being equal, while the Hills and Mountains zone shows higher use.

[23] Possibly because a number of households had left-over stock and contemporaneous prices do not reflect well prices that were effectively paid by farmers.

Table A.1 Associates of fertilizer use on paddy rice - Cragg double hurdle model - Average marginal effects

Variable	Unit	Model 1		Model 2	
		Coeff.	z-value	Coeff.	z-value
Household characteristics					
Decision maker					
Female				0.36	0.21
Age				-0.01	-0.21
Education level (default=Grade 5 or less)					
Grade 6-11	1=yes			1.94	1.14
>Grade 11	1=yes			5.28	2.03
Working hh members	number			0.85	1.27
Agricultural area owned	acres			0.09	1.06
Incentives					
Paddy price	Log(MMK/kg)	19.57	5.49	14.51	4.02
Urea price	Log(MMK/kg)	-13.08	5.55	-3.68	-1.12
Travel time center township	hours			-8.41	-6.21
Travel time city>50,000 p.	log(hours)			-19.64	-14.34
Other controls					
Upland area	1=yes			7.97	2.42
Agro-ecological zone (Delta = default)					
Dry Zone	1=yes	-3.03	-1.67	-0.61	-0.35
Coastal Area	1=yes	-9.41	-3.23	9.27	2.43
Hills and Mountains	1=yes	3.22	1.34	12.11	4.46
Time					
Year 2021	1=yes				
Number of observations		5,193		5,191	
Pseudo R2		0.00		0.02	

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