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Constraints on Sustainable Growth in Agricultural Production in the Dry Zone of Myanmar

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Abstract

The objective of the study was to investigate changes in crop productivity and constraints in sustainable agricultural production in the area under Lat Pan Chay Paw irrigation projects located in Nyaung Oo township of dry zone of Myanmar. Questionnaire, key informant interview and focus group discussions were used to collect the data. The findings of the study showed that double and triple cropping systems were the major cropping systems in areas where irrigation water was accessed from the canal while single cropping was dominant in areas where irrigation water was accessed from private open wells. The farmers who used irrigation water from the canals were more likely to make profit through intensive agriculture than those from open wells. The major constraints in agricultural production in the study sites were labor scarcity and financial problems. Moreover, irrigation water shortage and conflicts in sharing of irrigation water were main issues in canal irrigated areas while high irrigation costs prevailed in private open wells. Therefore, this study recommends the water use efficiency, uniform distribution of water and formulation of better irrigation schedules for sustainable agricultural production.

Keywords: agricultural production, dry zone, Myanmar, sustainable agriculture

INTODUCTION

Identifying constraints on sustainable growth in agricultural production have implications for improving agricultural productivity and livelihoods of the farmers (Ladejinsky, 1976; Ruttan, 1991; Kraaijvanger et al. 2016; Wani et al. 2016; Zaongo et al. 1994). We in this study have tried to find out constraints to agricultural production for some key crops in the three different irrigated zones of Myanmar. In Myanmar, agricultural sector is the cornerstone of the economy as it contributes almost 40% of GDP, 70% of employment and about 25-30% of exports (Baroang 2013). Moreover, it plays a major role in economic growth of the country by providing the raw materials for agro-based industrial development (Kyi 2012). The central dry zone of Myanmar, which covers about 10% of the country's total area, is one of the most food insecure areas in the country (WFP, 2011). The area is susceptible to irregular rainfall and prolonged drought periods. Compared to other parts of the country, the average annual rainfall is very low, ranging from 500 mm to 1000 mm with high variability and uneven distribution (JICA, 2010). The local communities totally rely on the south-west monsoon for their livelihoods. As a consequence, the livelihoods of the rural people relying on agriculture are being threatened by crop failures and losses.

Rainfed agriculture is the main source of livelihood for 79% of farming households in the area (WFP 2011). In addition, land degradation due to a high risk of water and wind erosion is leading to declining in agricultural production (WFP 2011). Lack of access to credit, water and agricultural inputs, low soil fertility and poor agricultural practices are the major constraints for crop productivity and income (FSATG 2010). The government has prioritized the development of irrigation schemes since 1980s to solve the issues of water scarcity in the region. In 2012, in a government report, there were 67 river water pumping stations achieving 16.3 % of their target nationwide. Although there are irrigation projects for crop production, but they are not enough to meet the local food demands (Lwin 2014). This was due to a wide range of issues including the

system design, operation and maintenance issues, availability of power for pumping, and inappropriate siting and soils. In pumped systems, water cannot be pumped at the appropriate time due to shortage of electricity. This has caused conflicts among the farmers due to unequal water distribution (Johnston et al. 2013). The respondents selected for the study were from the main canal (MC), secondary canal (SC) and open wells (OW). The objectives of this study were to 1) assess the cropping systems, agronomic practices and agricultural water management 2) assess the changes in crop production and cropping intensity and 3) and to find out the constraints in the crop production in the study area.

RESEARCH METHODS

Study area

The central dry zone of Myanmar was selected as study area because agriculture is the major source for income generation and irrigated agriculture was practiced through pumping water from the rivers. Dry zone of Myanmar covers large parts of the Magway, Mandalay and lower Sagaing Divisions. There were 13 districts in central dry zone. Of these, Nyaung Oo district which was in Mandalay region was selected as study area. Nyaung Oo towinship is located in Nyaung Oo district with the population density of 198,185. It lies between North Latitude 21° 16' and East Longitude 95° 27' (Figure 1). The total area of township is 1,458.9 square kilometers (Department of Population 2015). The topography is generally undulating plateau with elevation of 150-200 m, and a number of steep hilly chains are at an altitude of 300-400 m (Department of Meteorology and Hydrology, 2009).

In dry zone, temperature is very high and fluctuates ranging from 15 ºC to 32 ºC. The annual rainfall and moisture depends on the South-West monsoon (Kahan 2001). Most of the dry zone area receives less than 750 mm of average annual precipitation which is below the national average of 2,353.06 mm. The most common soil types found in dry zone are clay, sandy loam and sandy soils (FAO 2003a). Generally, soils are infertile and

shallow (FAO 2006). Water holding capacity of the soils is low with a high level of evapotranspiration which limits the crop growth especially during the drought period (FAO 2003b).

Sample size

The sample size was calculated by using Yamane's (1967) formula with 10% error of tolerance and 90% confidence level.

Data Collection Methods

The type of research is exploratory type. Both purposive and random samplings were used to select the respondents. The study villages were first selected from Nyaung Oo district which is located in the central dry zone of Myanmar. Both primary and secondary data were collected. The primary data were collected by using structured questionnaires, focus group discussions (FGDs) and key informant's interviews (KIIs). The secondary data and were collected to support the primary data.

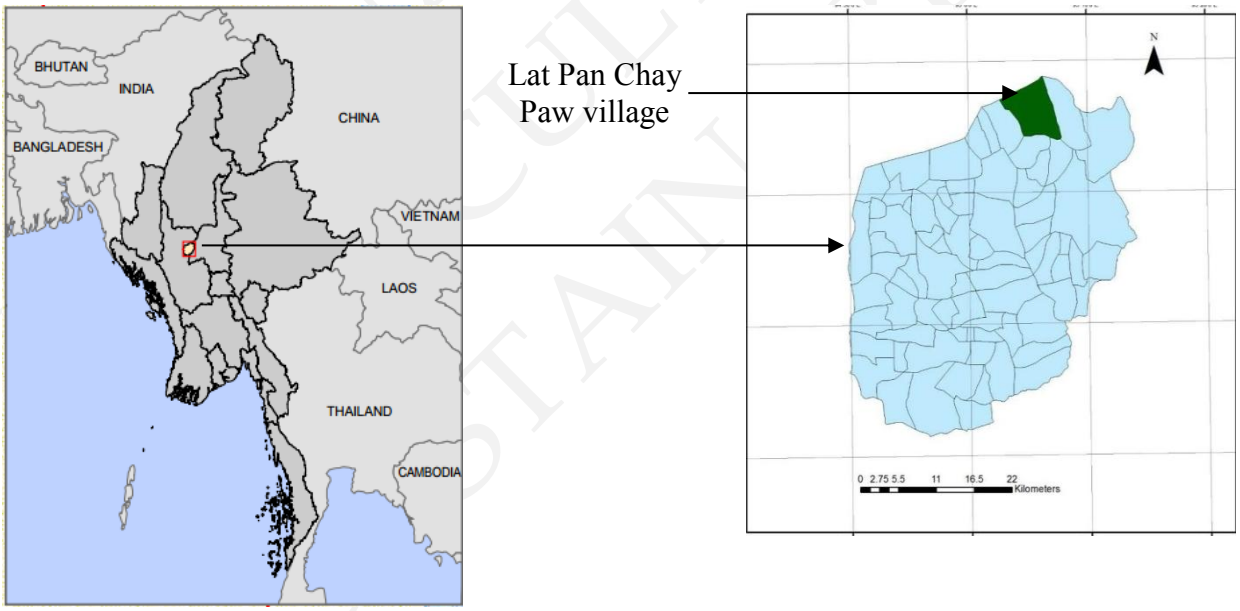

Figure 1: Location map of Myanmar showing study area in Nyaung Oo township, Myanmar

Data Processing and Analysis

Qualitative statements from KIIs and FGDs were analyzed by using qualitative statement analysis such as narrative analysis. To analyze the quantitative data, descriptive statistics were used. For data processing and analyzing, Microsoft excels and SPSS were used. Socio-economic conditions, irrigated areas, cropping patterns, agronomic practices, types of crop grown, agricultural water management, income and expenditure and cropping intensity were analyzed by using descriptive analysis such as bar graph, pie charts, frequency distribution, mean and percentage. F-test, T-test and χ^2 test were used to compare the agricultural productivity under different irrigated areas.

Calculation of the Profit and Cropping Intensity Index

In this study, crop productivity means the net return from the total crop production. Total expenditure per hectare included total input costs (seed, organic fertilizer, chemical fertilizer, pesticide, irrigation) and total labor costs for all field operations (from land preparation to postharvest processes). Total gross income per hectare was calculated by multiplying total yield per hectare and selling price per ton. Total profit per hectare was the difference between total expenditure and total gross income per hectare. Cropping intensity index was calculated by using the following formula from Rana, 2011 as indicated below.

$$\text{Cropping intensity index} = \left(\frac{\text{Sum of area under all crops in a year}}{\text{Net land area}}\right) \times 100$$

RESULS AND DISCUSSION

Profile of the Respondents

Male were more in number as compared to female in the study areas. Regarding education, about two-fifth of the respondents from MC had education up to secondary school level whereas one-fourth of the respondents were at the primary school level. In SC, the education levels of the respondents were mainly found at secondary school level while about half of the respondents were at primary and high school level. In OW area about 28% and 25% respondents were in primary and high schools respectively.

Regarding household size, it was found that in all the three areas, majority of the households were found in the range of 2-5 for MC, SC and OW. Regarding land holding size, majority farm sizes fall in the 0.19-5 hectare for all the three sites.

Agriculture Production in Different Irrigated Areas

Crop Calendars

The cropping patterns and types of crops grown were different based on the access to irrigation water. In the MC, there were four major cropping patterns i.e., 2 types of triple cropping and 2 types of double cropping. Summer rice and summer green gram were cultivated from the first week of March to the end of June while monsoon rice was cultivated from the first week of July to the second week of November. Chickpea was grown in the rice field with the residual moisture after harvesting monsoon rice. But, chickpea cannot be grown in all fields. Triple cropping was practiced by the households whose fields were near the source of water. In that place, rice was grown in monsoon and chickpea in post-monsoon season with the residual moisture in the rice field. In summer season, because of the insufficient of irrigation water, rice was not grown. Double cropping was practiced in the fields which were near the river and are always getting irrigation water because of the low level of soil surface. Therefore, chickpea cannot be grown in post-monsoon season. Furthermore, it was not grown if harvesting time for monsoon rice was late. In the SC, one type of triple cropping and two types of double cropping were practiced. Rice was not grown in summer season. Instead of growing of summer rice, farmers in SC grow green gram which required less frequency of irrigation water.

Triple cropping was practiced in fields which had easy access to irrigation water from the canal. Rice was grown in monsoon season, green gram in summer season and chickpea in post-monsoon season. Double cropping was practiced by 26.7% of households. Monsoon rice was grown by all farmers. But, some farmers could not grow summer green gram because their farms were located above the canal and it was

difficult to irrigate by gravity flow. Therefore, some farmers grew summer green gram by pumping water from the canal and some fallowed the land in summer season. Some others could not grow post-monsoon chickpea although it did not require irrigation water. This is because when monsoon rice was harvested later than normal harvesting time, it was not enough time to grow chickpea as post-monsoon crop. The OW was at the tail of the MC, the irrigation water was not available from the MC for crop production. Single cropping was the dominant cropping pattern in this area. The major crops which were grown as single crop include maize, chilli, tobacco and onion depending on the market and soil conditions. The cropping seasons of onion and chilli covered about three to four months and that of tobacco took about sixth months.

Area Cultivated for Crops Grown by the selected Irrigation Sites

In MC, among the crops grown, monsoon rice occupied a wide area of 1.19 ha per household, because the fields were near to the source of water. In summer season, the availability of irrigation water was not enough to distribute it to all fileds for rice cultivation. Therefore, the areas of summer rice and summer green gram were not as large as that of monsoon rice. Rice was grown in summer season where irrigation water was easily available. Green gram required less water during the whole crop growing period. Therefore, it was grown as summer crop even if the irrigation water was not available. The land which covered by chickpea was 0.94 ha (Table 1). There was no need of irrigation water for growing chickpea. After harvesting the monsoon rice, the residual soil moisture was enough to grow chickpea. Therefore, it was grown as a post-monsoon crop in winter season. Likewise, farmers wanted to grow it as a cash crop because it required fewer inputs. In MC, the fields which were at the tail of the canal and had no access to the irrigation water grew the crops which required less water. Chilli and tobacco were grown by irrigation water from private OW in the fields which had no access to irrigation water from the canal.

Table 1: Areas Cultivated for Crop Grown by Different Irrigation Sites

Crop	Crop grown area per household (ha ± S.D)			
	MC	SC	OW	F-test
Summer Green gram	1.01±0.75	0.60±0.41	0.52±0.31	p=0.013
Summer Rice	0.97±0.72	0.32±0.11	0.81	p=0.453
Monsoon Rice	1.19±0.98	0.59±0.39	0.74±0.12	p=0.005
Chickpea	0.94±0.74	0.57±0.37	0.72±0.46	p=0.074
Chilli	0.42±0.28	1.32±1.03	1.07±0.87	p=0.305
Tobacco	0.40±0.29	1.01	0.65±0.31	p=0.308
Maize	-	-	0.65±0.58	
Onion	-	-	0.26±0.19	

Source: Field Survey, 2015.

In SC, the area of monsoon rice per household occupied a large range of lands (0.59 ha) out of total households' crop grown areas. During summer season, green gram was the priority crop which covered a wide range of 0.60 ha per household among total crop grown areas. This is because the summer rice required large amount and many times of irrigation water. Moreover, green gram was a less water demanding crop. Sorghum was grown under rainfed condition. In OW, chilli was the major crop which occupied a large area of about 1.07 ha per household. The other priority crops were tobacco, maize and onion.

Agronomic practices in the MC

Summer Rice

Summer rice was mainly grown in the MC. Out of 54 households, summer rice was only grown by three households in SC and by one household in OW because they had access to the irrigation water from MC. Out of total households, almost 78% used both machine and draught animals for land preparation in MC. Nearly 18% of households used only draught animals for both ploughing and harrowing while 3.60% used only machines for land preparation. About three-fourth of total households did weeding operations about one to two times. The amount of seed rate used was 0.15 ton per

hectare. Most of the farmers used organic fertilizer before growing summer rice and they did not use it every year especially in the MC. Therefore, the amount of organic fertilizer applied was higher in summer rice than in monsoon rice. The rate of urea fertilizer application was 0.28 t/ha and that of compound fertilizer was 0.11 t/ha which were higher than that for monsoon rice to achieve potential yield. This is because the availability of irrigation water was less during summer rice cultivation than monsoon rice. Therefore, the organic fertilizer and chemical fertilizers were applied with high rate to get potential yield. Out of total households, 61.8% used machine in harvesting and threshing while 38.2% operated harvesting and threshing manually (Table 2).

Monsoon Rice

Land tilling was done by using draught animals or machine or both. Usually, machines were used for ploughing and then the ploughed lands were harrowed by using draught animals to break up the clods. Out of total households, almost 80% ploughed their lands with machine and then harrowed by draught animals while nearly 18% households used draught animals for ploughing. Land preparation was implemented by draught animals about 6 times for one acre. The farmers perceived that it increases not only water holding capacity of the soil but also leads to plant growth and weed control. Weeding was carried out by majority of the farmers. During the whole cropping season, the fields were weeded about 2 times. The amount of seed used was 0.15 t/ha. Organic fertilizer (cow dung) was added to the fields in every two or three years. However, it was not used in some fields which were far from the farm road and carts were difficult to get to the fields. About 3 t/ha of cow dung were applied for every two years. The amount of urea fertilizer (0.26 t/ha) was higher than that of compound fertilizer (0.08 t/ha). This is due to the fact that nitrogen is an important element for the growth of the rice plant. In harvesting and threshing operations, about half of the total growers used combine harvester and the rest of them harvested and threshed the plants by hired labors (Table 2).

Table 2: Agronomic Practices for summer rice, monsoon rice, summer green gram and chickpea in the MC

Agronomic Practices	Summer Rice (N=55)	Monsoon Rice (N=82)	Summer Green gram (N=52)	Chickpea (N=44)
1. Land Preparation				
Draught animal (%)	18.20	18.30	53.80	19.00
Machine (%)	3.6	1.20	11.5	59.50
Draught animal + Machine (%)	78.20	80.5	34.6	21.40
Total	100	100	100	100
Ploughing and Harrowing (times/cropping)	5.15	5.76	3.88	1.44
2. No weeding (%)	30.9	4.90	38.5	97.8
3. Weeding (%)	69.1	95.1	61.5	2.20
Total	100	100	100	100
4. Weeding (times/cropping)	1.19	1.87	0.88	0.02
5. Seed rate (t/ha)	0.15	0.15	0.04	0.14
6. Fertilizer Rate				
Organic (Cow dung) (t/ha)	4.71	2.97	0.45	0.09
Urea (t/ha)	0.28	0.26	0.04	0
- Compound (t/ha)	0.11	0.08	0.002	0.001
7. Harvesting				
- Machine (%)	61.8	48.8	0.00	0.00
- Manual (%)	38.2	51.2	100.00	100.00
Total	100	100	100	100
8. Threshing				
- Machine (%)	61.8	48.8	32.7	79.5
- Manual (%)	38.2	51.2	67.3	20.5
Total	100	100	100	100

Source: Field Survey, 2015.

Summer Green gram

Over half of the total households used draught animals for land preparation. Among them, about one-third ploughed the lands with machine and then harrowed by draught animals. The times of land preparation performed by draught animals were 4 times. The frequency of ploughing was about 4 times. In that area, most of the farmers carried out weeding operations which represent almost 61%. All households used urea fertilizer with the rate of 0.04 t/ha and compound fertilizer with 0.002 t/ha. Some farmers used organic fertilizer (cow dung) in green gram cultivation. Majority of the growers harvested the grains manually but about 33% threshed the grains by machine.

Chickpea

About two-thirds of the households used machines for land preparations for chickpea cultivation. One-fourth of total households ploughed the land by using draught animals and another one-fourth used machines for ploughing and draught animals for harrowing. Ploughing and harrowing was performed about 2 times per season. Almost all farmers did not carry any weeding operation. The rate of seed used per hectare was 0.14 t/ha. The applications of fertilizer were less but pesticides were used by almost all farmers. For chickpea cultivation, agronomic practices such as ploughing and harrowing, weeding, fertilizer application were not required too much. Therefore, farmers wanted to grow chickpea as a cash crop. All chickpea growers harvested the plants manually. Threshing was implemented with machine by majority of the farmers.

Agronomic Practices in SC

Monsoon Rice

In SC, half of the total households used machines for ploughing and draught animals for harrowing. Another half of households ploughed the lands by using draught animals. Ploughing and harrowing were implemented by draught animals about 10 times for one acre. Farmers from SC had access to the limited amount of irrigation water. Therefore, the famers used more seed rate which accounts for 0.22 t/ha. Cow dung was used at about 6.84 t/ha. Out of total households almost 87% carried out

weeding about 2 times through the whole cropping season. The application of urea fertilizer was 0.34 t/ha and compound fertilizer was 0.12 t/ha. To get potential yield, high rates of fertilizer were applied with the limited amount of water during the crop growing period. Among the total growers about 93% harvested the rice plants by hired labors while only 6.7% used combine harvester because there was no combine harvester. As the area under rice cultivation was much larger, it was difficult to hire combine harvester (Table 3).

Summer Green gram

For the summer green gram, the use of draught animals was dominant and done by about three-fourth of total households. Land preparation was performed by draught animals about 5 times per cropping season. Out of total households, about 64% carried out weeding operations to get good plant growth. Urea and compound fertilizer was applied at a rate of 0.03 t/ha and 0.002 t/ha, respectively. Most of the farmers used organic fertilizer only once for every two or three years. All growers carried out the harvesting operation manually. However, about 57% of total growers used machine for threshing while about 43% threshed by man power (Table 3).

Chickpea

For chickpea, out of total households about two-third implemented land preparation by using machine to catch moisture after harvesting monsoon rice. Out of total households, 13% use both machines for ploughing and draught animals for harrowing, and about 26% of households ploughed and harrowed the land about 2 times by using draught animals. Weeding operation was not carried out. For one hectare of cultivated lands, the amount of seed rate was 0.15 t/ha. Organic fertilizer and compound fertilizer were not used. Only less amount of urea fertilizer was used with the rate of 0.005 t/ha. Nevertheless, pesticides were used by almost all farmers. This is because agronomic practices such as ploughing and harrowing, weeding, fertilizer application were not required too much for chickpea cultivation. Harvesting operation was performed by

hired labors. Out of total growers, about 35% carried out threshing with machine while about 65% did it manually (Table 3).

Table 3: Agronomic Practices for Monsoon Rice, Summer Green gram and Chickpea in SC

Agronomic Practices	Monsoon Rice (N=30)	Summer Green gram (N=28)	Chickpea (N=23)
1. Land Preparation			
Draught animal (%)	50.00	74.10	26.10
Machine (%)	0.00	11.10	60.90
Draught animal + Machine (%)	50.00	14.80	13.00
Total	100	100	100
Ploughing and Harrowing (times/cropping)	9.69	5.44	2.23
2. Did not practice weeding (%)	13.30	35.70	100.00
3. Weeding (%)	86.70	64.30	0.00
Total	100	100	100
4. Weeding (times/cropping)	1.53	0.79	0.00
5. Seed rate (t/ha)	0.22	0.03	0.15
6. Fertilizer Rate			
Organic (Cow dung) (t/ha)	6.84	0.00	0.00
Urea (t/ha)	0.34	0.03	0.005
- Compound (t/ha)	0.12	0.002	0.00
7. Harvesting			
- Machine (%)	6.7	0.00	0.00
- Manual (%)	93.3	100.00	100.00
Total	100	100	100
8. Threshing			
- Machine (%)	6.7	57.1	34.8
- Manual (%)	93.3	42.9	65.2
Total	100	100	100

Source: Field Survey, 2015.

Agronomic Practices in OW

Chilli

Chilli was a dominant crop grown in OW area. Half of the total households implemented land preparation by using both machine and draught animals. According to the respondents, two-thirds of the farmers owned draught animals. Land preparation was applied for about 6 times during a single cropping season. Out of total households, almost 33% used machine and about 17% used draught animals. All chilli growers carried out weeding. The amount of seeds used was 2.65 t/ha. Some farmers did not use seeds and cultivated only seedlings. They used high rate of organic fertilizer of about 7 t/ha for each growing year not only in the field but also in seedbeds because single cropping covered a wide range in that area. Urea and compound fertilizers were also used with the rate of 0.22 t/ha and 0.12 t/ha respectively (Table 4).

Tobacco

Most of the farmers owned cows and that is why 61% of total households used draught animals for land preparation before sowing the crop. One-third of the households used both machine and draught animals whereas about 8% households used machines. The lands were ploughed and harrowed about 17 times per cropping season. Weeding and inter-cultivation were operated by about 92% of total households. Most of the farmers planted over 13,140 seedlings per hectare. Rate of organic fertilizer was about 12 t/ha while 0.22 t/ha and 0.12 t/ha for urea and compound fertilizer respectively (Table 4).

Maize

Half of total households operated the land preparation by using machine for ploughing and draught animals for harrowing. About two-third of the households used only draught animals whereas about one-third conducted land preparation by using only machine. Land preparations were implemented about 6 times for maize. All farmers did weeding and inter-cultivation about 2 times. The amount of seed rate was 0.08 t/ha. The amount of urea and compound fertilizer were the same. Half of the total growers implemented the threshing operation with machine (Table 4).

Onion

Onion was also grown in OW. Before sowing the crop, land preparation was operated about 6 times by one-fourth of total households by using machine whereas thee-fourth of the households were using only draught animals. Out of total households, 80% conducted the weeding operation about 2 times during the whole crop growing period. For growing one hectare of onion, the farmers used 1.07 t/ha of seed. As organic fertilizer, about 16 t/ha of cow dung was applied for one hectare while 0.41 t/ha and 0.06 t/ha of urea and compound fertilizer (Table 4).

Agricultural Water Management

Figure 2, shows the frequency of irrigation water for each crop in different irrigated areas. As mentioned before, summer green gram, summer rice, monsoon rice and chickpea were grown under irrigated area in the MC and SC. Out of total chickpea growers in all irrigated areas, only one household used irrigation water only one time because monsoon rice in his field was harvested earlier than the adjacent fields. For summer green gram, the fields were irrigated about 2-6 times in MC, 2-7 times in SC and 3-4 times in OW. For monsoon rice cultivation, the frequency of irrigation water was higher in the MC than in SC. Even if the frequency of irrigation water was the same in both canals, the amount of irrigation water was not the same. This is because the irrigation water for SC was pumped from the MC. If the farmers from the MC opened the irrigation outlets to their fields, the irrigation water for SC was not enough for distribution of water to all fields. In MC, the average frequency of irrigation water was 12 times for summer rice and 11 times for monsoon rice. As chilli, tobacco, maize and onion were irrigated from the private OW, time and amount of irrigation water can be adjusted with the time of crop requirement. Actually, the fields from OW were the planned irrigated areas of the MC. Nevertheless, these were so far away from the MC to irrigate for the crop production, especially for rice crop. Therefore, the farmers selected the crops that needed less water.

Table 4: Agronomic Practices in OW

Agronomic Practices	Chilli (N=12)	Tobacco (N=13)	Maize (N=10)	Onion (N=5)
1. Land Preparation				
Draught animal (%)	33.3	61.5	37.5	75.0
Machine (%)	16.7	7.7	12.5	25.0
Draught animal + Machine (%)	50.00	30.8	50.0	0.00
Total	100	100	100	100
Ploughing and Harrowing (times/cropping)	5.54	17.06	5.55	6.15
2. No weeding (%)	0.00	7.7	0.00	20.00
3. Weeding (%)	100.00	92.3	100.00	80.00
Total	100	100	100	100
4. Weeding and Inter-cultivation (times/cropping)	3.42	3.15	2.00	1.08
5. Seed rate (t/ha)/(plants/ha)	0.02	13140	0.08	1.07
6. Fertilizer Rate				
Organic (Cow dung) (t/ha)	6.86	11.90	4.40	15.67
Urea (t/ha)	0.22	0.22	0.06	0.41
- Compound (t/ha)	0.12	0.12	0.06	0.06
7. Threshing				
- Machine (%)	0.00	0.00	50.00	0.00
- Manual (%)	100.00	100.00	50.00	100.00
Total	100	100	100	100

Source: Field Survey, 2015.

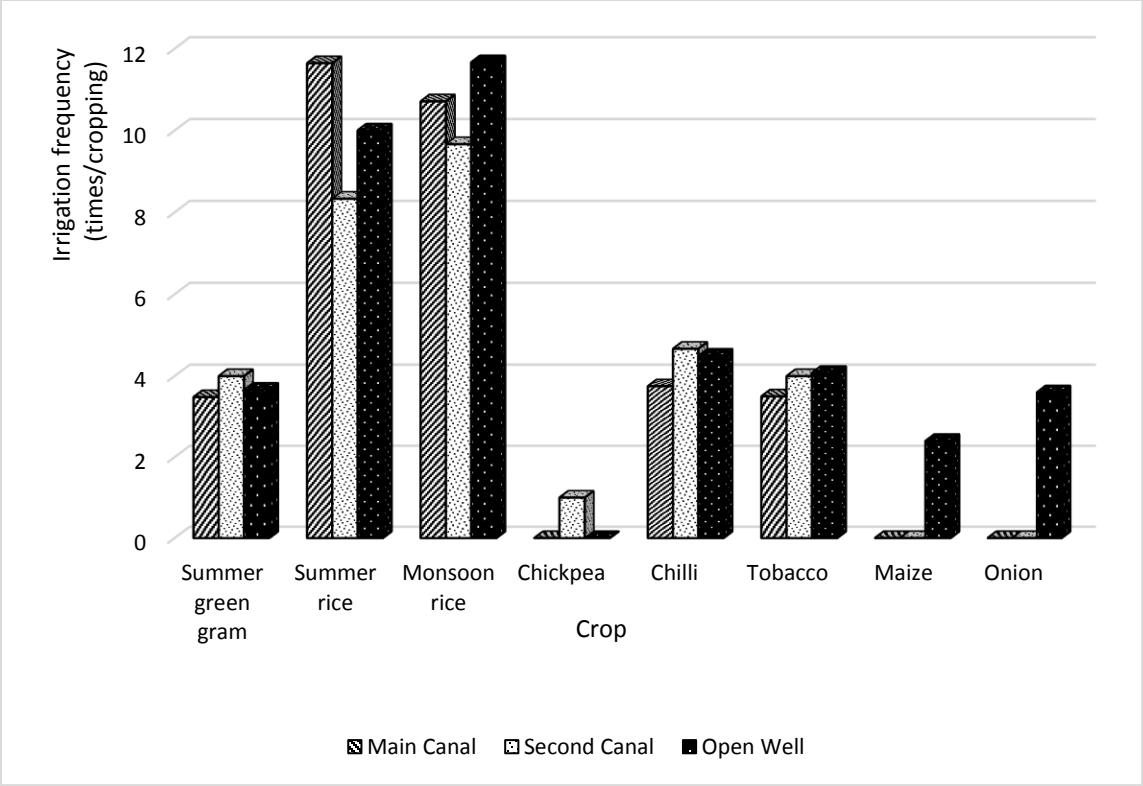

Figure 2: Frequency of irrigation for each crop in different irrigated areas

Crop Productivity in the MC

Summer Rice

The average yield per hectare was 5.38 t/ha, however, it varied based on the agronomic practices, soil conditions and frequency of irrigation water during crop growing period. In case of shortage of irrigation water, the yield was reduced to 1.85-2.47 t/ha. The average gross income per household was 1,116.83 dollars per hectare. Out of total yields, about third-fourth was sold while 22% left for home consumption and 5% for seed based on their cultivated area. Therefore, growing rice was helping their food sufficiency. For all total growers, the average net profit was USD 272.61/ha. Out of total summer rice growers, 49 households gained net profit with average value of USD 309.81/ha.

Monsoon Rice

The average yield per household was 4.41 t/ha. Farmers kept the paddy for their home consumption and seed for coming growing. Most of the farmers sold about three-fourth of total production and the rest were used for home consumption and seeds. The average total income per household was 939.79 USD/ha and the average profit was USD 183.01/ha.

Summer Green gram

The average yield was 0.90 t/ha ranging from 0.03 to 2.2 t/ha because farmers bought the varieties which were not suitable for their condition from the brokers. Accordingly, even some farmers did not get any grain and harvested only vegetative parts for fodder. Green gram growers got the average gross income of USD 860.03/ha. The average net profit was USD 327.62/ha. Accordingly, there were significantly differences in income per hectare. Therefore, some farmers could make profit while others did not any return from green gram cultivation.

Chickpea

The average yield was 0.82 t/ha, ranging from 0.39-1.16 t/ha. The total income per hectare was USD 377.20/ha. The average net return was USD 87.43/ha. However, out of total growers, 34 households could make a profit by growing chickpea with the average revenue of USD 132.61/ha while 10 households lost revenue which accounts for USD 66.18/ha.

Crop Productivity in SC

Monsoon Rice

The average yield was 4.43 t/ha. More than half of the total yield were sold where about two-fifth were used for home consumption. Out of the total yield, only 3% was left as the seed for next monsoon season. The gross income per season of monsoon rice cultivation was USD 991.04/ha. The average net revenue was USD 154.45/ha and it was different among farmers depending on their investments in crop production, agronomic practices, and soil conditions.

Summer Green gram

The average yield was 0.67 t/ha with the range of 0.12-1.62 t/ha. The average total income per households was USD 645.51/ha. The net profit for all growers was USD 143.11/ha which was different among farmers who were getting profit and losing by growing green gram. For the farmers who got the profit, the average net profit was USD 386.78/ha while those who got net negative profit was USD 156.65/ha. The main reason was the yield differences between profit and loss groups. Although there were not significantly differences in production costs per hectare, income per hectare became different due to the differences in yield.

Chickpea

The average yield was 0.66 t/ha with minimum yield of 0.19 t/ha and maximum yield of 1.45 t/ha. The average gross income was USD 299.78/ha. The profit for chickpea cultivation was USD 14.91/ha. Over half of the total growers achieved net profit (USD 113.58/ha) and about half of them (USD -69.45/ha) lost the production costs.

Crop Productivity in OW

Chilli

There was a wide variation in yield ranging from 12.35 to 494 baskets. Because the chilli fruits were bitten by rodents after fruit setting in some fields and some plants were not harvested due to the incidence of virus during the crop growth period. Consequently, the income per hectare became different among households. The average total income per hectare from chilli cultivation was USD 597.39/ha. Out of the total chilli growers, only 17% made the profit whereas 83% did not cover the production costs. The average net positive profit was USD 418.65/ha while the average net negative was USD 702.06/ha because of yield differences and consequently differences in income per household.

Tobacco

The average yield was 2.27 t/ha and all harvested yields were sold by all farmers. The average gross return per hectare was USD 1643.35/ha. For all growers, the net profit per hectare was USD 464.10/ha. Out of the total households, 15% cannot make the profit while 85% got the profit by growing tobacco. The yield differences of these two groups were 2 times because the plant population per hectare and the rate of organic fertilizer were higher in profit group than in loss group. As a consequence, the income per household became higher in profit group.

Maize

The average yield was 3.17 t/ha with a wide range of 0.19 to 5.13 t/ha and all the outputs were sold to the market. The average total income per hectare was USD 778.06/ha. Among the total growers, 40% gained the profit of USD 294.87/ha from one hectare of cultivated land and 60% lost USD 217.60/ha. The major differences between the profit and loss came from the input costs and labor costs.

Onion

The yield had a wide range with 1.61-12.92 t/ha. This is because the amounts of seed rate, organic and chemical fertilizer rate were different among households. Among the total growers, 40% sold all outputs while about 60% left 6% of the total harvest for home consumption and 94% for sale. The average total income (USD 854.27/ha) was less than the total expenditure in all total growers. Therefore, no one cannot cover the production costs. The total production costs per hectare for onion cultivation were too high due to the high input costs such as seed, pesticide and high labor costs particularly weeding, land preparation, pesticide spraying and harvesting. Moreover, the market price for onion was fluctuating after one year to year. Therefore, the growers took risks by growing onion. According to the information from FGD, farmers didn't want to grow onion in the next coming years.

Crop Intensity

Table 5 showed that the crop intensity index in different irrigated areas. According to the result, there was a significant difference in crop intensity index at 99% level of confidence. The higher cropping intensity can be found in both the MC and SC. There was no difference in cropping intensity in these two areas. It can be interpreted that, in both areas, at least two crops per year can be raised on the net sown area because of the availability of irrigation water for both summer and monsoon seasons. In OW, most of the farmers could raise only one crop in one agricultural year. This is because they did not get the irrigation water from the canal. However, they raised the crops with irrigation water from the private OW. The costs of irrigation water were higher than that from the farmers who accessed the irrigation water from the canal. Therefore, they can grow only one crop per year. In the rest of a year, the lands left fallow because of the lack of canal irrigation water. As a consequence, cropping intensity was lower than other two irrigated areas (Table 5).

Table 5: Crop Intensity in All Irrigated Areas

Irrigation Status	Cropping Intensity	SD	F-test
MC (N=94)	247.43	84.32	
SC (N=31)	246.37	62.13	p=0.000**
OW (N=32)	120.79	40.44	

**Significant at 0.01 confidence level

Constraints in all irrigated areas

The constraints encountered in crop production in all irrigated areas were based on the information from KIIs and FGDS. FGDs were conducted in all irrigated areas. The Lat Pan Chay Paw irrigation project was started in 1968. At first, that project was under department of irrigation and aimed for cotton cultivation. However, the production costs of cotton did not cover the total expenditure due to the selling price of cotton was

too low although the production costs were high. Therefore, farmers encountered loss of farms, cows and other possessions. As a consequence, some farmers became landless. In 1995, the policy was changed to cultivate rice in that area to get rice self-sufficiency at local level. Therefore, the construction of irrigation canal systems and size of the irrigation pipe was not suitable for rice production. In 2000, under Lat Pan Chay Paw irrigatied project, SC irrigated areas have been expanded to get full self-sufficiency. The target area under that project for rice production was 607.29 hectare. But, after expansion of buildings and constructing the bridge, the target area was decreased to 404.86 hectare.

The availability of irrigation water was different among farmers within the MC. This is because only two generators were operational. Moreover, the size of the pipes was not the same in the whole irrigation canal system. Consequently, there was no pressure in large size pipe to push water out into the canal and then the irrigation water was not distributed equally. In the MC and SC, there were many irrigation outlets. Under one irrigation outlet, the irrigated areas range from 1.42 to 9.72 hectare. If there were more irrigated areas in one irrigation outlet, the sharing of irrigation water was high causing the insufficient of irrigation water have been found among the farmers.

There were two types of distribution of irrigation water: alternative system and depending on water demand from the farmers. If irrigation water was distributed according to the demand of farmers, the more conflicts were found among the farmers. This is because when those at the tail of the canal opened their irrigation outlet without their turn, the farmers at the head of the canal had no access to the irrigation water completely. Those conflicts were to be solved by water committee. The irrigation water for SC was pumped from the MC. Therefore, if the farmers from the MC opened their irrigation outlets without their turn, the water could not be pumped up to the SC. Under such situation, the farmers from SC faced irrigation water shortage problem. If the irrigation water was not enough for the crop growing period, the rice yield was less

than 1.24-2.47 t/ha of the potential yield. In summer season, there was less water in the river. Consequently, the shortage of electricity was encountered during summer season. That caused the reduction of the crop yield in per unit area. Moreover, as another constraint, in summer season, the pipe had to be reset up to pump water from the river when the river water is declining and rising up. It occurred about minimum 10 times in one year. At that time, the irrigation water was not distributed to the fields.

In both the MC and SC, labor scarcity usually has been found in monsoon rice cultivation. Moreover, farmers owned rainfed cultivated areas which were not under the Lat Pan Chay Paw irrigation project areas. When harvesting time from irrigated areas and rainfed areas overlapped, labor scarcity became the major constraints in both areas. Also, the amount of credit access for rice cultivation per hectare was USD 203.68/ha and USD 40.74/ha for other crops. Although the credit was accessed two times per year, that amount was not enough for one hectare of rice production. Therefore, farmers borrowed money with high interest rate to invest for their crop production. After harvesting their crops, they have to pay those debts with high interest rate. Therefore, they did not cover the production costs.

In OW, the major constraint was the high cost for irrigating the field for crop production. It was 10 times higher than those from MC and SC. According to the result of FGD, as long as the use of irrigation water from the OW for crop cultivation, the soil cannot hold water properly. Therefore, cow dung and chemical fertilizer were used with high rate depending on the crop type. It made high production costs per unit area. In addition, the amount of credit was accessed only one time per year which account for USD 40.74/ha. That amount was too low for one hectare of crop cultivation especially with high irrigation costs. Therefore, financial problem is the major constraint for the farmers from OWarea. As another constraint, at harvesting time, a lot of farmers had labor scarcity due to the migration of the youth to abroad to work. Therefore, the labors were hired in advance.

CONCLUSION AND RECOMMENDATION

In all irrigated areas, there were differences in cropping systems and patterns based on the source of availability of irrigation water. Double cropping and triple cropping systems were in use in both the MC and SC. In OW, single cropping system was the dominant system because irrigation water was available from private OW and irrigation costs were too high for crop production. Depending on the source of availability of irrigation water, the crop grown areas were different in the three irrigated areas. Farmers from the MC had got higher profits because of double and triple cropping systems. The farmers from SC and OW had less profit from their crops. Therefore, the highest cropping intensity was found in MC followed by SC and OW. The constraints faced by the farmers included irrigation water shortage, labor scarcity and financial problems. To increase income and profit from the agricultural crop production in irrigated area, implementation of land leveling, soil amendment and support for short duration varieties should be encouraged by the government. The government authorities should make arrangements to enhance water use efficiency and efficient water distribution. To increase the cropping intensity, the practice of intercropping systems such as drought resistant pigeon pea with other legumes should be introduced in OW. Farm mechanization should be widely promoted in all irrigated areas to solve the labor scarcity. It could also save time among the cropping seasons and consequently could also reduce the loss of soil moisture for raising the succeeding crops. Credit should be provided by the government with large amounts per hectare to reduce the financial burden in their crop production.

Conflict of Interest

The authors declare that no conflict of interest exists.

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