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Differential impacts of an irrigation project: Case study of the Swar Dam Project in Yedashe, Bago region of Myanmar

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In Myanmar, the government has made a vast investment in the construction of dams to improve crop productivity and to ensure socioeconomic development. This study explores the differential impacts, in terms of socioeconomic conditions, of these investments for paddy farmers in Yedashe Township, in the Bago region in the south-central part of Myanmar. A farm survey among 95 respondents is used to compare the situation before and after the construction of a dam. It is observed that after the installation of the dam, the farmers could practice double rice cropping enabling them to gain higher income. The impact of the dam project on the employment rate, paddy yields and incomes were measured using normalized vector equations. A positive effect on all these factors was observed. The incomes of the farmers increased by benefiting from higher crop productivity, more crops per year, and more benefits over variable costs. However, the return above variable cash costs (RAVCC) and the benefit over cost (BC) ratio of head-end users was significantly higher than that of middle-reach and tail-end users. Therefore, the study additionally explored the problems of unequal water access and farmer-oriented solutions to these problems. The lack of monitoring and management of the irrigation institutions was found to be a major constraint for the development of the irrigation sector. Therefore, efficient utilisation of irrigation water by water-users, and policies as well as investments in the development of irrigation infrastructure need to be emphasised.

Key words: Irrigation dam, downscaled water users, disequilibrium, impact assessment.

INTRODUCTION

Myanmar is one of the largest countries in South-East Asia with a total area of 676, 577 km². The total population is nearly 52.42 million with an annual population growth of 1.01%. The agricultural sector is the backbone of Myanmar's economy, and it contributes 26% (2011 to 2012) to the gross domestic product (GDP); it

represents 16.4% of total export earning; and it employs 61.2% of the labour force. About 40 million people (nearly 66% of total population) live in rural areas and their livelihoods depend on agriculture or related income sources (DAP, 2013; DAP, 2014). The agricultural sector in Myanmar is dominated by paddy cultivation.

The production of rice relies on a favourable ecosystem with adequate water supply. Irrigation water availability therefore is an important and essential part for the production of rice (Bouman, 2012). In Myanmar, access to irrigation water for rice cultivation is particularly crucial during the dry season (Naing et al., 2008; Naing, 2011). Therefore, governments have included construction of irrigation facilities in their regional development plans (Zaw et al., 2011). Past and present governments have invested in water resource management through storage of water in dams or reservoirs. Up to now, 241 dams have been constructed to increase irrigated crop production throughout the nation, and to control flooding (DAP, 2013; DAP, 2014).

With the increasing scarcity of water resources, investments in water availability and water management facilities are becoming essential for many countries. For the implementation and monitoring of equitable water distribution, sufficient collective action is required to promise an efficient water use and maintenance of the quality of irrigation canals (Meinzen-Dick et al., 2002). The overall benefits of improved irrigation facilities and its related externalities for the society should be studied.

This requires assessing the complex adjustment of social, biophysical and economic factors. Such assessment is also necessary for Myanmar (Naing, 2011). In order to accurately evaluate the effect of irrigation, it is needed to assess the corresponding economic consequences (Paredes et al., 2014).

The construction and rehabilitation of irrigation systems basically aims to increase rice production, and to have sufficient production of other crops. The general benefit of these systems extends over different sectors in Myanmar. However, because of a lack of systematic management of the dam and the lack of proper management of irrigation canals as well as a failure of monitoring and policy implementations by the irrigation sectors in Myanmar, water demand is not met throughout the growing season. The rice yields are unstable and falling due to insufficient water access in the later maturity stages of rice mainly for the tail-end rice growers (Naing, 2011). In this context, it is relevant to study the effect of irrigation on different water users and to compare the benefits and costs for the irrigated farms.

In Myanmar, water users groups (WUGs) and water users associations (WUAs) play an important role in the management of irrigation water and the development of irrigation dams. However these organisations still do not function well. Lack of proper monitoring, control and maintenance of the dam and the irrigation system leads

to decreasing water supply for downstream water users, to a deterioration of the irrigation system, and a defective water control. This, in turn, tends to diminish the irrigated area and final crop production.

Therefore, with the aging of the irrigation dams it is also relevant to evaluate whether the irrigation facilities are still able to meet the water demands of the farmers. Due to the lack of assessment of the costs and benefits of dam projects in Myanmar, the roles of dams in rural development as well as the livelihood impacts are still unclear. And thus, the assessment of the impact of irrigation dams on the socioeconomic conditions of rice growers should be a critical topic for the rural development in Myanmar. The present research aims to assess the direct impact of the construction of a dam on employment, yield and income of paddy farmers in Yedashe Township, Bago region in the southern central part of Myanmar.

CONCEPTUAL FRAMEWORK

The assessment of the benefits and the costs of irrigation dam investments, deals with evaluating the economic value and societal benefits brought by this intervention. This economic impact assessment should include several sectorial linkages such as changes in productivity, changes in cropping patterns, changes in microeconomic variables like employment rate, changes in cost-benefit ratios, and changes in related crop incomes. Such an extensive assessment is necessary as large-scale irrigation development is usually initiated in view of a broad socioeconomic and regional development, and has an impact on many other sectors of economy too (Hussain and Bhattarai, 2002).

The significant impact of irrigation projects on society through several social aspects such as households conditions, educational level, social welfare expenditures, and overall livelihood development and poverty reduction were observed by many authors (Turral et al., 2010; Khan and Shah, 2012; Kresovic et al., 2014, Wichelns, 2014).

In this study, we assumed that the introduction of the Swar dam project might affect the social and economic characteristics of paddy farmers in the following ways:

(1) Receiving of irrigation water from the Swar dam may indirectly improve farm incomes by improving agricultural practices, in terms of changing cropping intensity and cropping patterns, and increasing paddy production.
(2) The Swar dam project might indirectly affect society in many ways. It may have impacts on the educational level, livelihoods assets, household' expenditures, different forms of social relationship and coherence. The impact of the dam on for example conflicts between irrigators, on inequality of water access needs to be assessed.

Irrigation projects and their related activities can also have environmental impacts: it may for instance lead to soil and water pollution. Such environmental impacts are however beyond the scope of this study.

Therefore, this study hypothesizes that farm incomes of the paddy farmers change after the instalment of the irrigation dam and that it is expected that there are differences in paddy yields and profits of the farmers before and after the instalment of the Swar dam. As mentioned before, not all farmers in the Yedashe Township have full access to irrigation water for their farming practices. We therefore also focused on problems of irrigation water availability. In this perspective, the Swar dam was selected to assess the effects of an irrigation dam on crop production and on the socioeconomic characteristics of farmers located at different distances from the dam in Yedashe Township in Myanmar. This study may highlight institutional characteristics and constraints in using irrigation water from the Swar dam. It also looked at coping strategies of farmers to assure adequate irrigation water supply for paddy production.

MATERIALS AND METHODS

Study area

The study was performed in the Yedashe Township, which is located on the northern edge of the Bago region. The Bago region is the second most important production area of rice after the delta region and it is a lowland irrigated rice production region in the south- central part of Myanmar. The annual rainfall in this region is about 2513 mm with 78.5% of mean relative humidity (DAP, 2013). The Yedashe Township is located between 95°50' to 96°30' East longitude and 19°5' to 19°30' North latitude. This region is part of the central plains ranging from South to North, and is bounded in the West by the Yoma mountain range and in the far East by the Shan mountain range. There are 19 village tracts that receive irrigation water from the Swar dam (Figure 1).

Four village tracts namely Kwingyi, Thapyaytan, Konegyi and Doetan were selected and the basic statistics of the selected village tracts are presented in Table 1. The total land area is about 3300 hectare of which 83% approximately 2757 hectare is cultivated with rice. In 2014 the total population was approximately 11500. The annual production area for paddy was about 2700 ha under monsoon production and 2150 ha under summer production (Table 1).

Paddy is a major crop in Yedashe Township and covers about 32991 hectare. In Figure 2, the production area of monsoon and summer rice is presented. In the past, summer rice was cultivated with residual water from monsoon precipitation. A sharp increase in the production areas of summer rice was observed after the instalment of the Swar irrigation dam in 2003. However, the rice yields are found to be very unstable and relatively low. The average rice yield is 607 kg per hectare in monsoon season and about 625 kg per hectare in the summer season[1].

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[1]Source: Department of Agriculture, Yedashe Township, Bago Region, Myanmar (2014)

Agro-ecological condition

The Yedashe Township has a tropical monsoon climate. There are three distinct seasons in Myanmar, summer season (March to April), rainy season (May to October) and the cold and dry winter season (November to February). The Yedashe Township has an average elevation of 12 meter above sea level. In the summer period, the average temperature is 38°C at noon, but in the winter season, the average night temperature is about 15°C. The 20 years rainfall data showed a mean precipitation of 2038 mm (±395 mm), and the mean number of days with precipitation was observed to be 97 days (±11 days) in the study area. In the wet season, the highest rainfall peak can be observed in July.

Sometimes, the peak is delayed until late September. In the summer season, the extremely weather events make it difficult to cultivate the rice.

Sampling and data collection

The study was conducted with paddy farmers in the Swar dam project areas in Yedashe Township. Four village tracts out of the nineteen village tracts were purposively selected because these village tracts are strategically located. Based on their location, three irrigation water user strata can be identified: head-end users, middle users, and tail-end users.

During the selection of the four village tracts, the suggestions of the Township Agricultural Service workers, and field team leaders were acquired, but in the end the data was sourced from a random survey. The four tracts Kwingyi, Thapyaytan, Konegyi and Doetan have received irrigation water from the Swar Dam since the project started in 2003. The fieldwork was conducted from April to May 2014. The Kwingyi village was located close to the dam and its inhabitants are regarded as head-end users. The Thapyaytan and Konegyi village tracts were located somewhere around the middle and inhabitants are therefore recorded as the middle reach users (Table 2).

The Doetan village tract was situated the furthest from the Swar dam. This is where the irrigation canal from the dam project stops. The inhabitants of this village are considered as tail-end users. The questionnaire covering the socio-economic characteristics of farm households such as incomes, family size, and other relevant variables as well as farm productivity, and problems and solutions related to water availability from the dam were prepared. A face-to-face interview was carried out with farmers and data were obtained from the farmers. In total, 24 head-end users, 44 middle-reach users and 27 tail-end users were interviewed (Table 2).

Direct impact assessment

Cost-benefit analysis is widely used in economic analysis and a vast majority of methods are applied. It is used to assess the profitability of an investment or a certain project. This can help to decide whether additional funding for the operation or extension of the project must be obtained (Patah and de Carvalho, 2007). But, the direct impact assessment is a simple way of assessing the correspondent impact of activities.

The direct impact of increased irrigation water availability on the production, farm incomes, and employment rate can be evaluated by using normalized vectors of these variables (Martinez et al., 2013). The direct impact caused by the instalment of the Swar dam on the income of the paddy farmers (***Vinc***), on the production capacity (***Vr.inc***), and on the employment rate (***Vemp***) can then be expressed as follows:
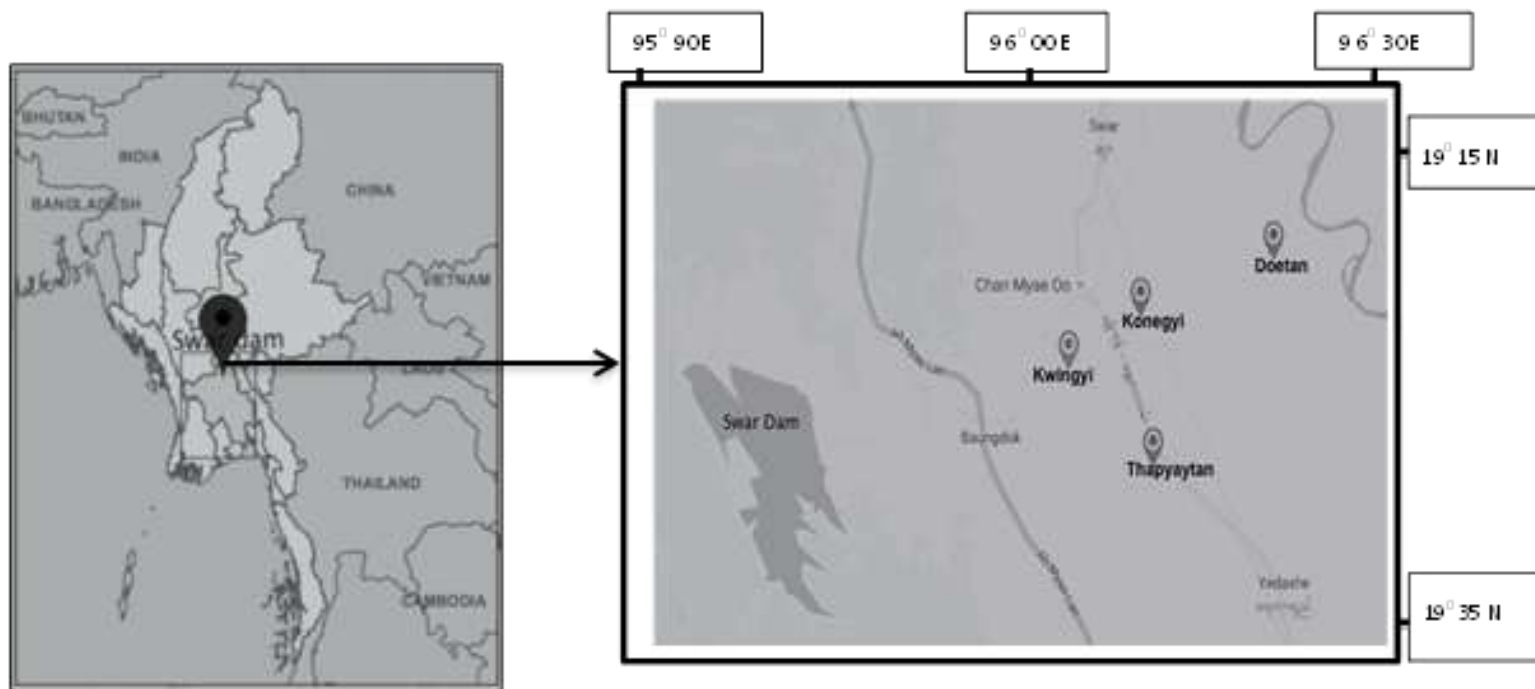
Figure 1. Map showing sampling areas and location of Swar irrigation dam in Yedashe Township (Source: Acknowledgement of the MIMU[2]).

Table 1. Four selected rice production village tracts under the Swar dam project.

Village track	Number of households	Total cultivated land (ha)	Rice cultivable area (ha)	Monsoon rice production area (ha)	Summer rice production area after the instalment of Swar dam (ha)	Total population		
						Male	Female	Total
Kwingyi	437	626.453	595.697	542.278	555.633	1095	1093	2188
Thapyaytan	390	834.462	773.759	773.759	733.290	826	891	1717
Konegyi	661	904.877	690.798	690.798	597.316	1645	1714	3359
Doetan	898	921.064	715.079	715.079	263.045	1998	2227	4225
Total	2386	3445.898	2757.123	2721.915	2149.285	5564	5925	11489

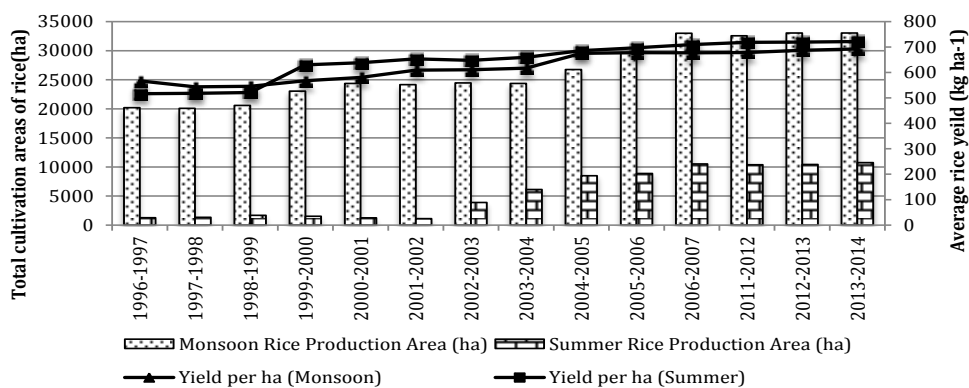[2] Myanmar Information and Management Unit

Figure 2. Total area of rice production and average yield (kg ha⁻¹) in the study area.

Table 2. Sampling of respondents from different group of the water users.

Village tract	Number of villages	Selected households	Water users	Percentage (%)
Kwingyi	5	24	Head-end User	25.3
Thapyaytan	3	21	Middle reach User	46.3
Konegyi	6	23		
Doetan	5	27	Tail-end User	28.4
Total	19	95	-	100.0

$$\Delta Vinc = wnr\Delta X$$

$$\Delta Vr.inc = Rnr\Delta X$$

$$\Delta Vemp = enr\Delta X$$

Where, w_{nr}, R_{nr} and e_{nr} are respectively the normalized vectors of income changes, production capacity changes, and changes in employment with the elements $wnr_i = w_i/x_i$, $Rnr_i = R_i/x_i$, and $enr_i = e_i/x_i$, respectively. Here, (X) factor represents the total output, 'i' represent the capacity of the sector, and 'x' represents the output of each sector.

This study assumed that farmers make a series of production choices aimed at maximizing profit at farm level and the farm households, however, are price takers and hence individual farmers have no impact on market prices. Hemson et al. (2008) addressed that a market-pricing method is suitable for financial or private cost-benefit analysis. To avoid the variation in market price, this study used the current market prices for the comparison of costs and benefits of paddy production between the situation "before" and "after" the instalment of the dam.

However, the aggregate net revenue per hectare (€ ha⁻¹) depends upon the output of rice crop, input prices and purchased inputs. Therefore, in the calculation of the benefits and costs, the change in productivity method can be used alternatively to derive the imputed value by providing the prices of other inputs and outputs. In the study, descriptive analysis, cost-benefit analysis, as well as a functional analysis was included.

Productivity and sensitivity analysis

In irrigated crop production, water is used as an input and thus the value of water can be derived indirectly using the economic concept of the production function. This is known as the change in productivity method, or residual imputation method, or change in net income method, which can be used to derive the shadow price of water, when knowing the prices for other inputs and outputs (Hussain and Bhattarai, 2002). The change in productivity method equation can be presented as follow:

Benefit or Value of Irrigation Water$= NVO_w - NVO_{wo}$;

Then, $NVO_w = GVO_w - C_w$, *and*

$$NVO_{wo} = GVO_{wo} - C_{wo}$$

Where, '*NVO*' is the net value of output, '*GVO*' is the gross value of output, '*C*' is the total cost of production, *subscript 'w' and 'wo'* represent with and without the irrigation water from the dam. The traditional cost-benefit analysis is often used as a tool for impact assessment, but it is very sensitive to the quantities and prices of inputs used in the production processes (Hussain and Bhattarai, 2002).

In this case, a sensitivity analysis can be apportioned to different sources of uncertainty in its inputs. Sensitivity analysis deals with the change in the quantity of total physical product resulting from a unit change in a variable input, keeping all other inputs unchanged. It studies the change in the quantity of total physical product resulting from a unit change in a variable input, keeping all other inputs unchanged (Komleh et al., 2011). The rice production functions in the study area were calculated according to Zangeneh et al. *(*2010) and Komleh et al. (2011).

Hussain and Bhattarai (2002) state that the change in cropping

intensity and the interaction with an irrigation intervention could attribute directly to the benefits of irrigation. In order to determine the benefits in terms of farmers' income, the benefit over cost ratio and the return over variable cash costs were also calculated. The benefit-cost ratio (BC) is commonly used in cost-benefit analysis and expresses in monetary terms the overall value of a project. The BC takes into account the amount of benefits or gains by performing a project and the costs to execute it. The benefit over cost ratio is calculated according to Komleh et al. (2011).

Overall, the assessment of the impact of a project can be evaluated using several methods, including cost-benefit analysis, productivity analysis, sensitivity analysis, etc. Each method has its own strengths and weaknesses. Therefore this study combined varies methods to give a reliable and holistic picture.

RESULTS

Socio-demographic characteristics and impact of irrigation water availability

The socio-demographic characteristics of the water user groups are provided in Table 3. The average age of the farmers in the study area did not differ a lot over the three groups and ranged from 51 years to 56 years. Farming experience determines the skills and the efficiency of the individual farmer to produce a certain output. In the study area, the mean farming experience of the farmers was above 29 years, and average family size was around 4.

The direct impact of extended irrigation water availability on the production functions, farm incomes and employment rate were calculated by the normalized vectors of unit change equations. Crop production requires labour input throughout the production process. The results indicate that the normalized vector values of change in employment rate for the head-end user was an average vector unit of 0.375 before the construction of the dam and about 0.667 after the intervention. The change in employment rate increased also for middle-reach users and tail-end users (Table 4).

The production capacity of the paddy famers also increased. An increase in paddy yield of the head-end users, middle-reach users and tail-end users' was observed. Due to the improvement in production capacity and gross output, the income of paddy farmers increased. After the construction of dam, the change in farmer's income was observed with an average increase of about 3 times higher in all the water users.

Production input of the paddy farmers

In Myanmar, agricultural sector heavily relied on farm laborers and draught cattle for land preparation, weeding, fertilization, water management and harvesting, as agricultural mechanization was not yet developed much (Naing et al., 2008).

In irrigated regions, several farming activities generate employment for the local people. Before the dam project,

farm' households were not possible to achieve year round employment in the study areas. Due to the availability of irrigation water from the dam, farm' households are now able to cultivate paddy and other cash crops in their farms.

Therefore, the intensification of agriculture through double cropping patterns is a solution to achieve year round employment opportunities. In this study, the average family labor input used on a day basic (men per day) in the paddy production processes under single cropping season (before) and double cropping season (after) was estimated.

In Table 5, the mean family labour used before the project was 1.5 men day^{-1} among the head-end users and it was 1.708 men day^{-1} after the project. It is evident that after the irrigation dam project, the mean family labour inputs increased in all the water users groups and more men power is used on the farm, as summer rice cultivable is now possible.

Based on the differences between the situation before and after the instalment of the irrigation dam, the comparison of the costs and benefits of monsoon rice production among different water users is presented in Table 6. The average farm output of each individual farmer was calculated based on a cumulative productivity of paddy crop on a hectare basic.

Therefore, the differences in price of the water user groups were observed because the farm benefit (€ ha^{-1}) of each water user group was calculated on a basic of differences in yield return. The total costs of production of monsoon paddy was around 209 € ha^{-1} on average for both the head-end and middle reach user groups and 220€ ha^{-1} for the tail-end users before the dam project.

The farmer's fixed costs (non- cash cost) such as owned cattle and manure cost, their storage seeds, and family labor costs were considered and variable costs (cash cost) such as hired cattle, farm-machines and labor cost, purchased manure, fertilizer, and pesticide costs were included in the total farmers costs for the paddy production and calculated on a hectare basic. More cash and non-cash costs of production of paddy crop was observed after the dam project, and the total costs of production increased to a mean value of 242, 261 and 267 € ha^{-1} for the head-end users, middle water users, and tail-end users, respectively. The summer rice production costs were comparable among the three different water users and 267, 260 and 242 € ha^{-1}, respectively (Table 6).

Farm income and paddy production

The study highlighted not only the differences in farm income before and after the dam project but also the income differences between different water users. The study found that an average monsoon paddy yield of

Table 3. Social demographic characters of the different water users.

Social demographic characters	Head end users (n=24)	Middle reach users (n=44)	Tail-end users (n=27)
Age (year)	56.9	51.3	53.0
Min	40	26	28
Max	80	87	83
Farming experience (year)	29.7	30.1	31.4
Min	25	8	10
Max	45	63	61
Family size (mean number)	4.5	4.5	4.2
Mean number of male	2.7	2.1	2.1
Mean number of female	2.2	2.5	2.1

Table 4. Direct impacts of irrigation water availability: Comparison of the situation before and after the Dam project.

Normalized vector of changes	Head end users (n=24)		Middle reach users (n=44)		Tail-end users (n=27)	
	Before	After	Before	After	Before	After
Employment (labour per unit change)	0.375	0.667	0.103	0.307	0.389	0.796
Yield (€ per unit change)	8.019	8.853	4.508	5.098	5.539	6.095
Income unit (€ per unit)	0.389	1.388	0.433	1.432	0.420	1.421

Table 5. Comparison of mean family labor input under before and after the instalment of Swar dam.

Family labor input used in the paddy production	Head end users (n=24)	Middle reach users (n=44)	Tail-end users (n=27)	F-test
Family labor before the dam project (men day^{-1})	1.5	1.25	1.148	3.245 (0.043**)
Family labor after the dam project (men day^{-1})	1.708	1.386	1.593	1.779 (0.175)

3084 kg per hectare of paddy crop was found before the dam project and an average monsoon paddy yield of 3293 kg per hectare was observed after the dam project.

In summer, rice production, an average of 3447 kg per hectare of higher yield was observed. Therefore, a significant yield difference was observed before and after the instalment of irrigation dam. The study also observed that the average net farm income of the head-end and middle-reach users are respectively around 245 and 240 €/ha, which is much higher than that of the tail-end users (208 €/ha). Thus, irrigation can increase the annual benefits and farm income of farmers, but differences in water availability causes a spatial income differentiation. In order to clarify the benefits of the farmers' income, benefit over cost (BC) ratio and the return above variable cash cost (RAVCC) were additionally established.

According to the results, the RAVCC of the monsoon paddy production also increased after the introduction of the dam project, from 176 €/ha to 292 €/ha for the head-end users, from 179 €/ha to 282 €/ha for the middle water

users, and like 180 €/ha to 256 €/ha for the tail-end users.

This increase was statistically significant at 1% level with the paired sampled T-test. Irrigation intervention makes it possible to intensify the production of paddy crop in the study area. Before the dam project, the average cropping intensity of sampled farmers was about 109.4 units and almost doubled to 205.8 units after the dam project. For the summer rice production season, the BC ratio and RAVCC were compared among the different water users. The BC ratio and RAVCC of the different water users for the summer rice production, was higher than that for monsoon rice production.

This increase was statistically significant at 1% level with the paired sampled T-test. The study also showed that the cropping intensity ratio of the head-end, middle-reach and tail-end farmers increased after the instalment of Swar irrigation dam. In this way, the household income increased by benefiting from more output per crop, more crops per year, and ensuring more return over variable

Table 6. Paddy productions and income functions: before and after the dam project.

Benefit/Cost of production	Input/output	Before the dam project (Monsoon rice)			After the dam project (Monsoon rice)			After the dam project (Summer rice)		
		Head end users (n=24)	Middle reach users (n=44)	Tail-end users (n=27)	Head end users (n=24)	Middle reach users (n=44)	Tail-end users (n=27)	Head end users (n=24)	Middle reach users (n=44)	Tail-end users (n=27)
Benefit of production	Total farm income (€/ha)	143	142	138	245	240	208	289	275	253
	F-test		0.121			5.117**			3.289**	
	Yield (ton/ha)	3.36	3.38	3.46	3.67	3.55	3.67	3.89	3.79	3.72
	F-test		0.754			1.861			5.64***	
	Market price (€/ha)	105	104	104	133	141	130	137	141	140
	F-test		0.956			28.279***			3.155**	
	Gross benefit (€/ha)	352	351	358	487	499	457	530	536	521
	F-test		0.438			2.457*			1.862	
Cost of production	Total cost (€/ha)	209	209	220	241	260	267	242	261	267
	F-test		2.825*			13.819***			13.82***	
	Non-cash cost (€/ha)	32	37	41	47	43	48	47	43	48
	F-test		29.485***			7.681***			7.681***	
	Cash cost (€/ha)	177	172	179	194	217	219	194	217	219
	F-test		1.233			16.95***			16.953***	
Benefit over cost (BC) ratio	BC	1.705	1.693	1.633	2.024	1.974	1.781	2.209	2.056	1.948
	F-test		0.844			8.615***			6.824***	
Return above variable cash cost (RAVCC)	RAVCC (€/ha)	175	179	180	292	282	256	335	321	275
	F-test		0.104			4.544**			8.529***	
Cropping intensity (CI)	CI	106.2	108.3	114.0	203.8	203.532	211.531	203.75	203.5	211.53
	F-test		0.944			1.407			1.407	

*** = Values statistically significant at 0.01 probability level, ** = values statistically significant at 0.05 probability level, * = values statistically significant at 0.10 probability level.

costs.

Farmers' perception to problems and solutions related to the Swar dam

In this study, qualitative data assessed farmers' responses to water availability problems. Water availability is considered sufficient if it leads to the successful production of rice without water deficit. Water availability is considered low when there is limited availability of irrigation water from the Swar dam in the rice production season (Figure 3).

The study found that 51.9% of the tail-end users faced low water availability, while 54.2% of head-end users reported sufficient water availability as shown in Figure 3. 50% of the middle-reach users observed moderate water availability, while in the tail-end region, no farmers reported sufficient
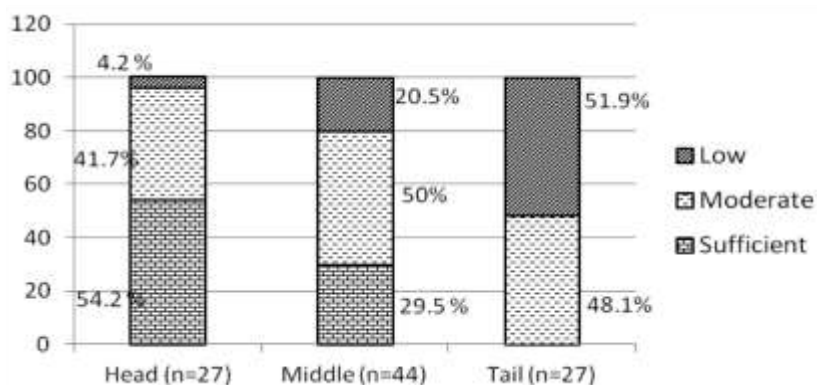
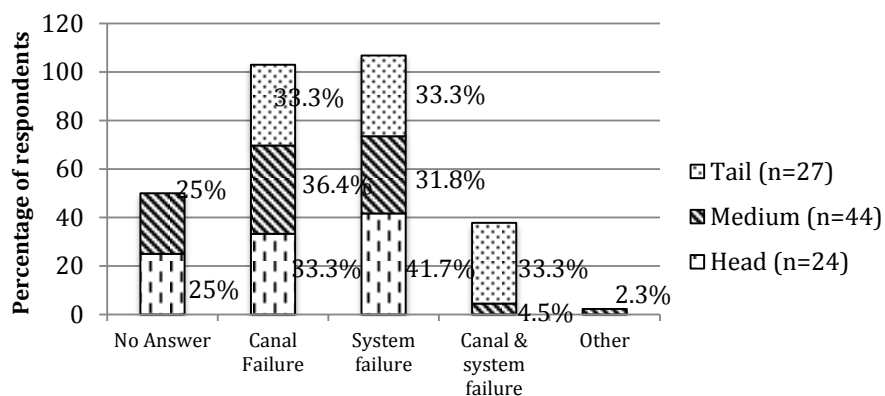**Figure 3.** Water users' perspective on irrigation water availability.

Figure 4. Problem reported by water users of the Swar Dam Project.

water availability.

Farmers' perception on the causes of water unavailability is given in Figure 4, 41.7% of the head-end users reported that insufficient water availability is experienced due to mismanagement of water distribution. 25% of the head-end and middle reach farmers did not report any causes. From both middle-reach users and tail-end users, about over 30% reported the canal failures and water system mismanagement are the major problems.

Farmers finally suggested solutions to improve water availability. Of the tail-end farmers, 48.1% mentioned that better water allocation is needed to improve water availability on their farms. They believe that an inadequate water distribution system is responsible for their water shortage. A better maintenance of the dam is required following 50% of the middle-reach users and 58.3 % of the head-end users, while a further 25 % of these users see an improvement of the irrigation canals as a major solution. As a results, 18.2% of the middle-reach farmers and 16.7% of head-end farmers reported yield fluctuations in the previous five years; while all of the tail-end users

mentioned that their crop yields highly fluctuated.

DISCUSSIONS

The study's limitations

This study was to assess the impact of the Swar dam project on different groups of farmers, and the changes in the socioeconomic status of paddy farmers. One of the limitations of the study is related to the before and after comparison. It was difficult for farmers to remember input use and income activities.

To overcome this, we used the "Record of Production of Individual Farmers"[3]. The study considered the farming productivity of farmers in the past ten years as a basis.

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[3] This book is commonly called 'the farmers' book" that record the paddy-sown acres, total output in yield, and the procurement quota for each year. This book is available amongst every farmer in Myanmar. (see also: *Okamoto, I (2008), Economic disparity in rural Myanmar: Transformation under Market Liberalization. Singapore: NUS Press/IDE-JETRO.*)

The fact that the townships' agricultural staff accompanied the researcher during data collection, and also improved collaboration of farmers. Furthermore, while it is not always easy to get access to secondary data or statistical data at the Township' Agricultural service and administration department, a recommendation letter by the regional administrator was helpful to get permission to access such secondary data.

Therefore by random sampling, having patience and spending a lot of time with the local farmers, regional agricultural professionals, servicing persons and by using different forms of assessing socioeconomic characteristics, data limitations could be minimized. This approach ensured to get more reliable data, and to produce valid results.

Irrigation and production input

In the study, the farm input was calculated based on fixed and variable production costs. Fixed costs were the farmer-covered cost or owned assets contributing to farm production. Fixed costs included owned draught animals for land preparation, family labour input, and manure obtained from owned animal, and storage of seeds for cultivation processes. The variable cost for agricultural production were such as number of cattle hired, additional labour input (non-family members), purchased manure loads, amount of urea and compound fertilisation bought / obtained, tractor or machines used for threshing and land levelling, and amount of pesticide used.

In both cases, the amount of fixed costs like farmer' owned cattle input, manure, family labor, and farmers owned-seed as well as variable costs like hiring cattle for ploughing, farm labor, and purchased manure, fertilizers and pesticides were calculated per hectare basic for each production type. The fixed costs of paddy production increased for all the different water user groups after the dam project.

As agriculture contributes greatly to employment opportunities in Myanmar, the problem of unemployment is normally higher in the off-season. This is because after the dam project, more family labor, farmer's owned cattle and manure inputs were used in the production of paddy crop, as double rice cropping is now possible in the study areas. The variable costs such as hired cattle, and hired labour also increased after the dam project as these inputs were more competitive at farm level and the price of hiring cattle and labor was expensive than before. In the study areas, when farmers have sufficient water supply, they can grow additional cash crops and practice intensive farming system to increase their family incomes. And hence, the productivity of land and labour is enhanced in the irrigated areas which contributes to higher household' incomes. Therefore our study confirms that agricultural water management generates local employment opportunities and provides a critical input to successful agricultural production as well as it enhances farmers' incomes which contributes to social and economic welfare of the farmers.

Farm income through irrigation

The direct impact assessment of this study showed that the irrigated summer rice production created more employment opportunities, higher farm incomes and higher yields. People residing nearby irrigation dams, can earn sufficient income from farm-related activities. Due to the introduction of an irrigation dam, the average farm labour in the agricultural production processes was increased as double rice crop production was possible which is comparable to the situation before the dam project.

Moreover, farmers are now possible to earn more income from alternative income sources derived from the sales of vegetables and fruits crops, production of food crops as well as incomes from the livestock rearing in the study areas. Accordingly, water availability through the instalment of dam inevitability benefited the local labour economy in many ways, especially by generating both farm and off-farm employment opportunities.

In general, the average yield of the summer paddy was higher than the monsoon paddy yield. However, also the average yield of monsoon rice farmers after the dam project intervention was higher than that of monsoon rice farmers before the dam project. Therefore, the study is agreed with Wichelns (2014) mentioned that the potential yield of grains are much higher under irrigation than in monsoon or rain-fed agriculture. Before the dam project intervention, farmers were solely depending on the production of monsoon or rain-fed rice. The study shows that in the monsoon season the average net farm income of farmers after the dam project was about 232 €/ha, while the average net income before the dam project was around 140 €/ha. Thus the irrigation dam project intervention increases the farm income through yield increases.

In addition, the benefit over cost ratio of the head-end users was higher than that of middle and tail-end users both in summer and monsoon paddy production. However, the different in the RAVCC and BC of the water users were observed after the introduction of the dam. The findings are consistent with Amarasinghe et al. (2008) that the benefit-cost ratio is much higher in head-end users because the net crop production benefit may vary across the canal reach.

After an irrigation dam intervention, although the contribution of production inputs could improve paddy crop productivity, some may argue that the presence of irrigation dam alone would not increase the productivity. For the reason, Hussain and Bhattarai (2002) mentioned

that the measurement on cropping intensity and the interaction of an irrigation intervention could attribute directly the benefit of irrigation.

The study results show that the cropping intensity ratio of the head-end, middle and tail-end users was increased almost double after the dam project intervention. Due to the intervention of the irrigation dam, farmers could practice double rice cropping pattern as well as enable to cultivate other food crops, vegetables and fruits crops in the study areas. In this way, household income is increased by benefiting more output per crop, more crops per year, and ensuring more return over variable costs with irrigation.

Constraints and amelioration of the Swar Dam

Water access inequality problems usually occur due to failures in the management of the irrigation system. Several research findings underlined the importance of irrigation for the socioeconomic conditions of farmers (Hanjra et al., 2009; Burney and Naylor, 2012; Giordano et al., 2012; Domenech and Ringler, 2013), and the difference in the socioeconomic characteristics of the different water users depending on the availability of water (Amarasinghe et al., 2008; D'Exelle et al., 2012; Kresovic et al., 2014).

Farmers reported destruction of canals and unfair and untimely distribution of irrigation water by the irrigation department as major problems. The Swar irrigation project has been running for a decade and the canals are in a bad state. In the study areas, the uncontrolled actions of the farmers such as blocking the canal and pumping out the water destroyed the earthen-type canals. The tail-end users face lack of access due to such canal closures or due to the head-end users' priority behaviour.

Often farmers see their seedling nursery destroyed by a lack of water and thus the production costs are increased because they have to restart nurturing. This happens due to a lack of systematic management and monitoring of the irrigation system. In the study, farmers in the tail-end region face severe water shortages in summer paddy production. The production capacity and gross farm income of tail-end farmers were lower than that of the middle-reach and head-end users. Therefore, effective coordination between the farmers and local authorities could remove the problem of water shortage.

This should focus on maintenance of infrastructure, enhancing the exchange of ideas, knowledge and new technologies.

CONCLUSIONS AND RECOMMENDATIONS

This study was performed among 95 households from four village tracts benefiting from the Swar irrigation dam in Yedashe Township in Myanmar. By using normalized vector equations, the direct impact of the construction of the dam on employment, yield and income was estimated and it was observed that the mean vector of changes of these functions were higher after the dam construction than before.

The study also found that the RAVCC of the farmers increased after the dam project and also the BC ratio improved. Therefore, we conclude that irrigation increases the production capacity of the paddy farmers, and assists more benefit in terms of investment costs per hectare of rice production. The study results indicate that farmers could produce more output per crop and more crops per year. However, a large yield variability was observed amongst the farmers. Among the different water users, the tail-end farmers seem to have lower water accessibility from the dam and the highest yield variability occurred in this group. There are lacks in managerial skills both among the water users and the managers of the scheme. The lack of monitoring and management of the local organisations or the irrigation institutions are constraints for the development of the irrigation sector.

Therefore, the government and local organisations should pay attention to yield stability for the paddy farmers. Farmers' awareness programs, training for efficient utilisation of water resource should be promoted. In addition, policies aiming towards the efficient utilisation of irrigation water, and investments for the maintenance and development of the irrigation infrastructure need to be emphasised to support the irrigation sector in Myanmar. The sample size in this study was rather small, therefore, more research and additional exploration with a larger sample size is needed to confirm the findings.

Furthermore, themes like the impact of irrigation water availability on different land holding categories (small, medium and large farm sizes), and the impact on environment and social aspects would be interesting to consider. Finally, the scope of water management through conducive managerial practices like water management education and training, on effective and efficient utilisation of irrigation water should be carefully studied.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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