

Possible Solutions to the Challenges of Irrigation Water Pricing for Saedawgyi Irrigated Area

Kywe Kywe^{a*}, Nilar Aye^b

^{a,b}*Department of Civil Engineering, Mandalay Technological University, The Republic of the Union of Myanmar*

^a*Email: kywekyweymt@gmail.com*

^b*Email: dnilaraye@gmail.com*

Abstract

This paper focuses on the possible solutions to the challenges of irrigation water pricing for Saedawgyi irrigated area in Mandalay Region. The current irrigation water pricing of Mandalay Region is necessary to reform as they could not cover the operation and maintenance cost of the supply system. For reforming irrigation water pricing, the challenges of irrigation water pricing for Saedawgyi irrigated area are identified as six major challenges based on previous study. Questionnaire survey is done to 307 farmers from Saedawgyi irrigated area for canal irrigation system to know the willingness to pay (WTP) of local farmers and price elasticity of irrigation water demand is evaluated by using mid-point formula. To solve the challenges of less maintenance and damaging of Infrastructure, proper training to local farmers and capacity building of the staff is essential for effective maintenance of the irrigation water supply system because the lack of professionals and staff training leads to deteriorate infrastructure. The possible solutions for remaining four challenges are proposed by studying the secondary academic sources such as papers, journals, and books. In this paper, six possible solutions are proposed for the challenges of irrigation water pricing in Saedawgyi irrigated area.

Keywords: irrigation water pricing; challenges; possible solutions; Saedawgyi Irrigated Area.

1. Introduction

Myanmar is an Agro-based country and agriculture sector is the backbone of its economy. Water use for agriculture is 91% of total water utilization system [8]. Agriculture water cannot be got sufficiently from rainwater in some part of the country. So, irrigation water has to be supplemented as agriculture water.

* Corresponding author.

Mandalay region, one of the regions of central dry zone, is cultivated different types of seasonal crops including paddy. To fulfill water demand for cultivated areas throughout the year, it is necessary to provide the efficient and long term developed water resources system [5]. In this study, Saedawgyi irrigated area are selected for canal irrigation system. The major crops cultivated in these area are monsoon paddy, summer paddy, chickpea, green gram, sesame, sunflower and black gram [4]. Water scarcity is one of the key problems in almost every part of the world [1]. Proper management and strong policy on sustainable development of water resources should be implemented to overcome water shortage problem. So, water pricing is considered as a significant economic tool in the reform process of water demand management [2]. Irrigated agriculture in Myanmar dates from the ninth century when low diversion weirs on the tributaries of the middle Ayeyarwaddy and small tanks were constructed to provide security for the monsoon season rice crop. In 1972, the Irrigation Department was formed to coordinate the development and management of water resources for irrigation. It gradually began to replace the earth diversion weirs of the traditional systems with more stable masonry or concrete structures, gate structures and lined canals. Now, most of these structures such as storage tanks, canal lining, tertiary-level canals and field ditches are used for many years and some parts are damaged. This results in insufficiency of water the fields. Although Myanmar has abundant water resources at present, there will be problems for the shortage of water in the future. The current water tariff system for canal irrigation is low and hence it does not recover the operating and maintenance cost [6]. Low cost pricing leads to over consumption of water and discharging large quantity of waste water. In order to develop and utilize water resources sustainably, justifying water pricing is necessary The role of water pricing for managing water resources is widely recognized in many areas of the world. It can contribute to higher water use efficiency and can provide financial resources for investing new water resources infrastructure and for sustaining the operation and maintenance of the existing water infrastructure. In the study area, the main irrigation infrastructure, including dams, weirs, and the water distribution system to farm level is constructed, operated and maintained by the Irrigation Department (ID). While many reservoirs and irrigation schemes have been built in recent years, some have not been fully developed due to shortfalls in the budget for construction of the canal network and structures. The existing water tariff is very low and does not cover the operating and maintenance cost. This leads to an inadequate funding for the maintenance and rehabilitation of the irrigation infrastructure. In 1972, the Irrigation Department was formed to coordinate the development and management of water resources for irrigation. It gradually began to replace the earth diversion weirs of the traditional systems with more stable masonry or concrete structures, gate structures and lined canals. Now, most of these structures such as storage tanks, canal lining, tertiary-level canals and field ditches are used for many years and some parts are damaged. This results in insufficiency of water to the fields. Therefore, this study intends to find possible solutions for the challenges to agriculture water pricing concerned with existing agriculture water tariff and use and it should be supported for the Myanmar National Water Policy in order that the Myanmar Water Law can be enacted.

2. Location of the Study Area

In this study, Saedawgyi Irrigated area is considered as canal irrigation system. Saedawgyi Dam is located near Saedaw village, Mattya township, Pyin Oo Lwin district, Mandalay Region. It is situated at North latitude 21' 57" and East longitude 96' 05" and its altitude is 74 m (240.5 ft). Its irrigated area is 93236 Acres [4]. This reservoir is constructed across the flow of Chaungmagyi river and divided into two separated canals. These are

Yenatha Canal, Mandalay Main Canal and the Chaungmagyi River which continues to flow towards the Ayeyarwady River. The Yenatha Canal supplies water into the northern irrigated areas. Mandalay Main Canal is used as water supply canal for both irrigation and domestic use of Mandalay city. Sedawgyi reservoir covers all irrigated areas of Mandalay city, Mattaya, Patheingyi and Amarapura townships. The irrigation network map of Saedawgyi irrigated area is shown in Figure (1).

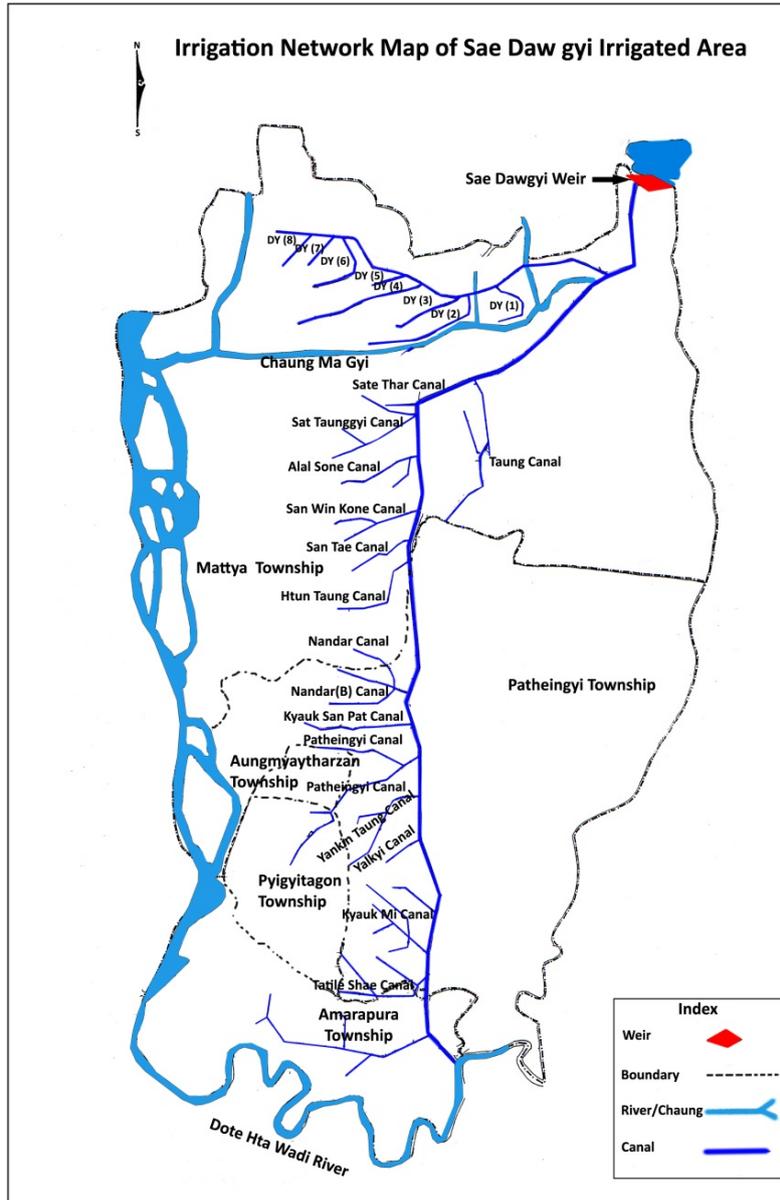


Figure1: Irrigation network map of Saedawgyi Irrigated Area

2.1 Existing Irrigation Water Supply System of the Study area

In Saedawgyi irrigated area, Mandalay Main Canal is used as water supply canal for both irrigation and domestic use of Mandalay city. Sedawgyi reservoir covers all irrigated areas of Mandalay city, Mattaya, Patheingyi and Amarapura townships. But, some of irrigated areas are not fully supplied to get its crop water

requirement. For example, the irrigated areas of Pathein Lay village in Mattaya Township do not get the irrigation water adequately from Nanda Distributary Canal of Mandalay Main Canal. Most of these structures such as storage tanks, canal lining, tertiary-level canals and field ditches are used for many years and some parts are damaged [7]. The Canal network system of Mandalay Main Canal is shown in Figure (2).

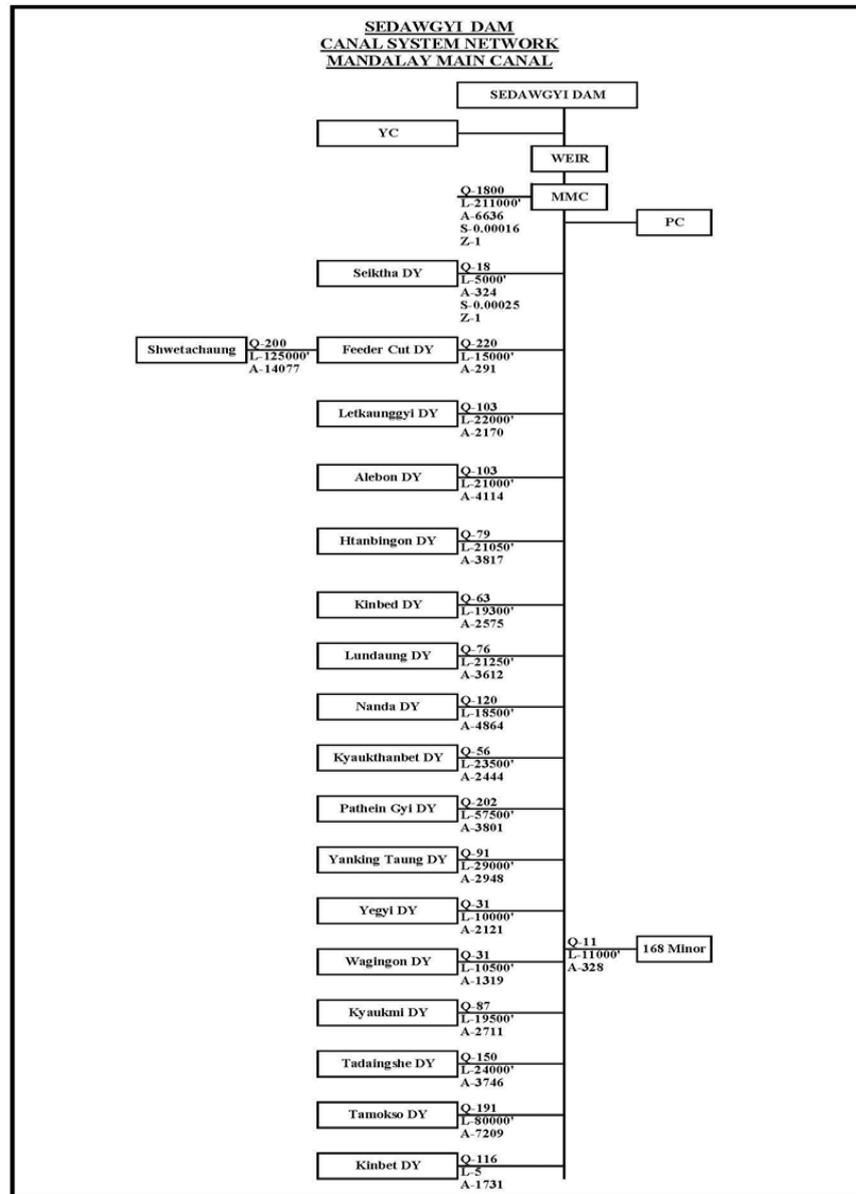


Figure 2: Canal Network System of Mandalay Main Canal in Saedawgyi Irrigated Area

3. Methodology

According to results of the questionnaire survey to local farmers, field investigation, and literature study, six major challenges related to agriculture water pricing for canal irrigation in the Saedawgyi irrigated area are identified. Situational analysis of existing irrigation water supply system is carried out to investigate the deteriorating infrastructures. Based on these situational analyses, the suitable solutions are proposed for the

study area. For the challenges of low water price, price elasticity of agriculture water use is evaluated using willingness to pay approach and then the new water prices for various crops are set up. Questionnaire survey and field survey has been conducted in order to get information the current irrigation water supply systems, farmers' willingness to pay (WTP), Demography and socio-economic data of 307 local farmers within the study area[3]. To solve the challenges of less maintenance and damaging of Infrastructure, proper training to local farmers and capacity building of the staff is essential for effective maintenance of the irrigation water supply system because the lack of professionals and staff training leads to deteriorate infrastructure. The possible solutions for remaining four challenges are proposed by studying the secondary academic sources such as papers, journals, and books. In this paper, six possible solutions are proposed for the challenges of irrigation water pricing in Saedawgyi irrigated area. The secondary academic sources such as paper, journals and books are used to propose the possible solutions for other challenges. Moreover, international solutions for water management help to get the possible solutions of irrigation water pricing in Saedawgyi irrigated Area.

4. Major challenges related to irrigation Water Pricing

According to results of the questionnaire survey to local farmers, field investigation, and literature study, six major Challenges related to irrigation water pricing for the Saedawgyi irrigated area are identified as follows:

- (1) Less maintenance and Damaging of Infrastructure
- (2) Climate Change Impact
- (3) Low Water Price for Irrigation Water Use
- (4) Canal Erosion and land Degradation in the field
- (5) Poverty
- (6) Lack of Communication and Adequate Capacity Building for the Water User Association and Member Farmers

5. Possible solutions to the irrigation water pricing for Saedawgyi Irrigated Area

In this study, six possible solutions for the challenges of irrigation water pricing for Saedawgyi irrigated area are proposed by the questionnaire survey to local farmers, field investigation, and the study of the secondary academic sources such as papers, journals, and books.

5.1 Possible solutions for the less maintenance and damaging of Infrastructure

The weir on Chaungmagyi river and its canal system had been introduced since the Bagan-dynasty, that is, since the 11th century, A.D. As such, the weirs and the canal systems had to be modified so as to be enabling to feed the increased acre-age of 95000 acres. The run-off of Chaungmagyi river during the dry weather period dwindles down to as low as 210 to 350 cusecs, and therefore, the scope for double cropping under this diversion

canal system is somewhat limited [4]. The need of a storage dam in the valley had to be seriously considered by the Irrigation Department. The main irrigation infrastructure, including dams, weirs, and the water distribution system to farm level is constructed, operated and maintained by the Irrigation Department (ID). While many reservoirs and irrigation schemes have been built in recent years, some have not been fully developed due to shortfalls in the budget for construction of the canal network and structures. The existing water tariff is very low and does not cover the operating and maintenance cost. This leads to an inadequate funding for the maintenance and rehabilitation of the irrigation infrastructure. Now, most of these structures such as storage tanks, canal lining, tertiary-level canals and field ditches are used for many years and some parts are damaged. This results in insufficiency of water to the fields. The damage of canal lining in the Saedawgyi irrigated area is shown in Figure (3) and (4).



Figure 3: Deterioration of canal Lining in Kyaukthanbet Canal, Mattaya Township, Saedawgyi Irrigated Area



Figure 4: Damage of Field-Ditch Canal in the fields of Pae Hlaw Pho Village, Mattaya Township, Saedawgyi Irrigated Area

To solve damaging of irrigation infrastructure, the following solutions are proposed for the study area within Mandalay region.

- (1) The main irrigation infrastructure, including dams, weirs, storage tanks, canal lining, tertiary-level canals and field ditches should be renovated, operated and maintained to raise storage capacity by the Irrigation Department (ID) and local farmers.
- (2) Problems with irrigation systems such as inappropriate design that prevents adjustment of water supply according to variations in demand over seasons, incomplete tertiary canals and on-farm networks, unlined canals with high seepage rates should be inspected in time and monitored regularly with complete coordination.
- (3) Improved engineering, technical and extension support, changes to crop selection and an increase in farmer involvement have been proposed as approaches to improve the performance of irrigation schemes.
- (4) Local farmers should be trained and discussed to construct and maintain tertiary-level canals and field ditches.
- (5) The schemes usually should have reasonably well-structured canal layouts: main canals, distributary canals and minor canals down to watercourse outlets.
- (6) A large number of direct outlets from the main canals which tend to receive a disproportionate amount of water resulting in relative shortages further down the system should be inspected and managed well.
- (7) A significant issue is that minor canals and direct outlets from the main canals are often ungated and this can substantially distort water distribution patterns: Therefore, Large canals need gated regulators. Because many regulators rely on stop logs rather than gates.
- (8) Sprinkler and localized irrigation has been developed only on a pilot basis by the Government of Myanmar. NGOs have financed a few small sprinkler systems and drip irrigation, and some private companies and better-off farmers use sprinklers. Due to their technical complexity and the high investment required, most farmers are still reluctant to try such technologies.
- (9) So, farmers should be trained to introduce modern irrigation technologies, regular maintenance of the system, a master plan should be developed for the irrigation network system.

Moreover, Proper training and capacity building of the staff is essential for effective maintenance of the irrigation water supply system because the lack of professionals and staff training leads to deteriorate infrastructure.

5.2 Possible solutions for Climate Change Impact

Myanmar has tropical monsoon weather with three distinct seasons; hot, rainy and cool seasons. Rainfall is strongly influenced by the monsoon, and annual totals vary from about 5,000mm in the coastal regions to less than 750mm in parts of the Central Dry Zone (CDZ). Myanmar's annual temperature ranges from 10°C to 32°C according to the topography of lands throughout the country.

The Study area, Mandalay Region, a part central plain of the CDZ has the hottest period has average maximum temperature of around 40°C with highest extreme values. It has the lowest annual rainfall, an extended dry season and infertile and sandy soils.

It has been reported that Mandalay Region has already experienced changes in its climate over recent decades. Average temperature is increasing within two decades. Longer dry seasons occur due to a decrease in the duration of the south-west monsoon season. The low rainfall and high temperature result in a chance of drought events.

Implementation of appropriate policies by local government and irrigation department needs to implement climate change adaption and mitigation strategies for water supply.

Reservoirs in the CDZ are annual rather than multi-year. This means that there is no expectation of storage being carried over from one year to the next (for water-years starting prior to the monsoon). However, the variability of the climate means that in some years there is significant storage remaining, and this influences the planning for the next irrigation season, in terms of the area to be irrigated or the choice of crops, and perhaps the date on which planting can begin.

Once the agricultural plans have been made, the plan for reservoir releases is prepared. With large areas to be planted with rice, which has a particularly large water requirement during land preparation, the theoretical water requirements (and hence required reservoir releases) are likely to be very high initially but to drop substantially as the cropping season proceeds. Unless the system is very well managed a pattern such as this may cause major difficulties for farmers when the releases are reduced. Consequently, it may in practice be better to plan a more even pattern of releases, implicitly forcing more efficient usage of water during the times of peak theoretical demand.

Climate change is having a considerable impact on the availability of water resources for agricultural production on the study area, the CDZ where the shortage of water is currently disturbing the stability and sustainability of agricultural production with respect to the drying tendency. Actual Evapotranspiration (ET) rate has slightly increased with acceleration in hydrological cycling under climate change. The increased crop water demand and intensified ET resulting from global warming will reduce water resources surplus in crop growth periods. Therefore, possible mitigation and adaptation measures should be assessed for enabling agricultural sustainability. It is revealed that reducing the sowing area of winter crop in water-limited areas and dry season.

Crops which has low water requirement should be cultivated in winter and summer when the climate is drying and water resources on the plain are decreasing seasons Improvement in crop water-use efficiency would effectively mitigate water shortages and intensify the resilience of agricultural systems to climate change.

Afforestation and forestation activities can also be a solution for the climate change adaption of the study area. When planted in upper watersheds, this process reduces runoff and soil erosion. Awareness program such as public talks should be carried out widely and frequently to the farmers in order to know that planting trees can support the sustainability of water resources.

5.3 Possible solutions for Low Water Price for Agriculture Water Use

The effectiveness of water pricing is regarded as an instrument for improving water allocation and reducing

water consumption. The existing water tariff is very low and does not cover the operating and maintenance cost. Low cost pricing leads to over consumption of water and discharging large quantity of waste water. Water is charged at a flat rate on the basis of land areas in these irrigation districts without volumetric facilities. This weakens the farmers' enthusiasm of adopting water-saving technology and water fee submission.

In canal Irrigation system, the water tariff is (1,950 MMK /acre/season) for paddy and (900 MMK/acre/season) for non-paddy crops. This system is gravity irrigation system. This price does not recover the cost of maintenance work across the country. Therefore, to set the new water price for the study area, the price elasticity of agriculture water use for various crops for the study area was evaluated by using willingness to pay analysis. Table (1) shows Unit Price and Mean WTP of Various Crop in Saedawgyi Irrigated area for Canal Irrigation System.

Table 1: Unit Price and Mean WTP of Various Crop in Saedawgyi Irrigated area

	Crop	Segment.No	Unit Elasticity	Unit Price(MMK)	Mean WTP(MMK)
1	Monsoon Paddy	5	-0.86	2106.9	2182.1
2	Summer Paddy	6	-1.1	2009.5	1966.5
3	Chickpea	5	-1.06	1400	1383.7
4	Sesame	4	-0.97	1779.9	1530.53
5	Green Gram	4	-1.08	1365.5	1401.1
6	Black Gram	4	-1	1252.9	1071.66
7	Sunflower	4	-0.99	1823.2	1846.91

The unit price values from price elasticity curves and the mean WTP values of monsoon paddy, summer paddy, chick pea, sesame, green gram, black gram and sunflower are nearly equal. Therefore, the unit price values from price elasticity curves for all crops are defined as the water prices for irrigation water pricing.

5.4 Possible Solution for Canal Erosion and land Degradation in the field

Land degradation in the study area is caused by water erosion, wind erosion, and soil fertility depletion. Land degradation, particularly soil erosion, is an increasing problem in dry zones due mainly to deforestation, poor agricultural practices, overgrazing and shifting cultivation

The main causes of land degradation include deforestation, poor agricultural practices, and shifting cultivation. In Myanmar the emphasis is still on physical, rather than vegetative, techniques for control of runoff and erosion. Techniques such as terracing often do little to increase production or incomes and have a high labor requirement. In drier areas such as the CDZ, however, where it is more difficult to implement vegetative methods,

To solve these problems, various soil conservation and land rehabilitation programs have been initiated through the Ministry of Natural Resources and Environmental Conservation (MONREC) and the Ministry of

Agriculture, Livestock and Irrigation (MOALI), in the CDZ.

Soil conservation measures carried out in project villages included construction of spillways, bench terraces, soil sedimentation bunds to protect village range land and farmland within project villages. In Myanmar the emphasis is still on physical, rather than vegetative, techniques for control of runoff and erosion.

Techniques such as terracing often do little to increase production or incomes and have a high labor requirement. In drier areas such as the CDZ, however, where it is more difficult to implement vegetative methods. Therefore, physical methods may be needed to help to become established and covered ground quickly.

5.5 Possible solutions for Poverty

The study area, which is located within the Central Dry Zone (CDZ), has the lowest annual rainfall, an extended dry season and infertile, sandy soils, but has with the second-highest population density in Myanmar.

Rural people affect mostly overcoming constraints such as deficient flood control structures, inadequate drainage, and soil erosion. Given that over 70 percent of the population lives in rural areas and primarily works in agriculture, low farm productivity translates into high rates of poverty and food insecurity.

The primary means of improving food crop production will be effected by extending and upgrading irrigation systems. To eliminate poverty of farmers in Saedawgyi irrigated area, improved engineering, technical and extension support, changes to crop selection and an increase in farmer involvement have been proposed as approaches to improve the performance of irrigation schemes. With improved management and a change in cropping patterns to non-rice crops, it would be possible to expand the cropping areas and cropping intensity. Farmers make more profit on a selected cultivation dry season crop which are more profit than paddy because of low water requirement and low labor and wise use of fertilizers.

5.6 Possible solutions for Lack of Communication and Adequate Capacity Building for the Water User Association and Member Farmers

Management, operation and maintenance of irrigation system are often poor due to staff shortages, inadequate budgets and lack of farmers' participation in decision-making. Much of the infrastructure on some large irrigation schemes is in poor condition. Absence of overall policies, legislation, and institutional structure for water resource management may lead conflicts and problems between government and farmers.

Due to the weak of policies and lack of legislation, some farmers convey water to their area by illegal conveyance means with use of sand bags and wood logs not to get water adequately to other cultivated fields Kyan Kin Village, Mattaya Township and is shown in Figure (5).



Figure 5: Illegal conveyance means with use of sand bags and wood logs in Kyan Kin Village

As above mentioned points create lack of communication and adequate capacity building for the water user association and member farmers related to Agriculture Water Pricing for Canal Irrigation in Saedawgyi Irrigated area.

To solve this, a capacity-building program has started, supporting Myanmar in building up knowledge on water management. Also, assistance and training should be provided by a number of workshops and training sessions which have been held with relevant organizations. The government gives irrigation development a high priority in order to increase crop yields and cropping intensity. Renovation of existing reservoirs to raise storage capacity and rehabilitation of existing government-maintained and village irrigation works, with a greater emphasis on efficient delivery of irrigation water and on-farm water management. Methods should be improved management and storage of water from streams and surface runoff during the rainy season. The participation of rural communities in the planning, implementation and subsequent management, O&M of irrigation works, flood control works and soil and water conservation activities is essential to their long-term sustainability. Minor canals and direct outlets from the main canals are often un-gated and this can substantially distort water distribution patterns. Therefore, large canals need gated regulators because many regulators rely on sand bags and stop logs rather than gates..

Moreover, water pricing topic should be discussed among farmers in the water user associations (WUAs) such as " how much water prices should be paid, how to collect data to improve the current irrigation Water supply system in the study area.

6. Conclusion

The existing water supply system of the study area needs to improve technical skills and to maintain water resources sustainability. Water pricing can provide financial resources that can be directly used for the protection of environment or for sustaining the operation and maintenance of the existing infrastructures. For

reforming irrigation water pricing of Mandalay Region, questionnaire survey is done to know the willingness to pay (WTP) of consumers. Situational analysis of the supply system is done to assess the challenges and possible solutions for irrigation water. For reforming irrigation water price, questionnaire survey is done to 307 farmers from Saedawgyi irrigated area for canal irrigation system to know the willingness to pay (WTP) of local farmers and price elasticity of irrigation water demand is evaluated by using mid-point formula. To solve the challenges of less maintenance and damaging of Infrastructure, proper training to local farmers and capacity building of the staff is essential for effective maintenance of the irrigation water supply system because the lack of professionals and staff training leads to deteriorate infrastructure. The possible solutions for remaining four challenges are proposed by studying the secondary academic sources such as papers, journals, and books. In this paper, six possible solutions are proposed for the challenges of irrigation water pricing in Saedawgyi irrigated area.

Therefore, the proposed solutions in this study are intended to improve sustainability of water resources for Mandalay Region and it is concluded that these solutions can be supported for the Myanmar National Water Policy in order that the Myanmar National Water Law can be enacted.

7. Recommendations

In this study, Challenges and possible solutions to irrigation water pricing are done for canal irrigation system due to time limitation and scope of research. Thus, agriculture water pricing should be developed for the whole Myanmar based on this study. For irrigation water supply system, price elasticity should be considered from supply side of view. In Myanmar, water for agriculture use is charged at a flat rate on the basis of land areas without volumetric rate. This weakens the farmers' enthusiasm of adopting water-saving technology. Therefore, water tariff system for agriculture water use should be volumetric rate.

Acknowledgements

First of all, the author wishes to express her deepest gratitude to Dr. Sint Soe, Rector of Mandalay Technological University for his encouragement and thankful suggestion. The author would like to express her gratitude to Daw Aye Aye Thant, Associate Professor of Civil Engineering Department, Mandalay Technological University, for her kind advice, true-line guidance and helpful suggestions. The author would like to express her heartfelt gratitude to Dr. Tin Tin Htwe, Professor of Civil Engineering Department, Mandalay Technological University for her supports, valuable suggestions and discussions during the presentation of the paper.

Special thanks are also extended to officers and staffs of Department of Meteorology, Mandalay Region and Ministry of Agriculture, livestock and Irrigation for providing the necessary data and facts for this paper.

References

- [1] Agriculture Water Pricing: Eu and Maxico

- [2] Jinxia Wang and Jikun Huang; Irrigation Water Policy in China
- [3] Questionnaire survey form from the project for the Farmers' Willingness to pay for improved irrigation in Tugela Ferry, KwaZulu Natal Province guided by the University of KWAZULU- NATAL (UKZN), South Africa.
- [4] Report on Sedawgyi Multipurpose Dam and Irrigation Systems; Irrigation and Water Utilization Management Department, Mandalay Ministry of Agriculture, Livestock and Irrigation)
- [5] Report of Water Resources assessment of the dry zone Myanmar
- [6] Report on Irrigation Development and Management, (Ministry of Agriculture, Livestock and Irrigation)
- [7] Yongsong Liao, Ziyun Bao: China's Water Pricing Reforms for Irrigation; Effectiveness and Impact
- [8] Zaw Lwin Tun; Irrigation and Water Utilisation Management Department, Ministry of Agriculture, Livestock and Irrigation, Myanmar