Developing an asset management plan for a sustainable future Indonesia irrigation systems

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Abstract

Since irrigation systems in Indonesia are faced with the problem of performance and sustainability, especially in rural areas, it is imperative to implement a sustainable and cost-effective Asset Management Plan (AMP). This AMP enables irrigation authorities to utilize and maintain the condition of its assets in the best possible way; to be kept running at a good operating standard, and provide a level of service that is consistent with cost-effectiveness and sustainability objectives.

The AMP framework was developed by integrating several methods. Initially, system performance was assessed through the internationally accepted method of Rapid Appraisal Procedure (RAP) and farmers' opinion survey. This combination was chosen to provide a more in-depth assessment by analysing the farmers' preferences so that the AMP framework can be developed with the elements to increase local support, co-operation, and benefit. Then, it was analysed further by adopting the Triple Bottom Line (TBL) principle to develop a sustainability framework. Finally, the AMP framework was built by utilising a modification of the method proposed by the Institute of Irrigation Studies (IIS) – University of Southampton and a participatory process in setting the level of service and timeframe of implementation.

Performance of rural irrigation systems is generally poor. However, the farmers are quite satisfied with the current services yet they expect improvement in the future. The TBL framework indicates that the systems to be sustained require modernisation of the irrigation systems and better irrigation system management, procedures, and communication by improving participation in irrigation management. Eventually, the AMP framework incorporate Water User Associations (WUAs) to make more efficient use of irrigation water and cost-effectiveness in maintaining the assets, especially at a tertiary level.
Keywords: performance assessment, TBL sustainability framework, AMP.

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1 Background of asset management plan for sustainable irrigation

According to the FAO, the world's irrigation systems produce 40% (by weight) of the world's food supply and crop production in the developing countries is projected to increase 175% in 2030. However, there are issues of irrigation water and land sustainability. Agriculture water consumption (almost entirely for irrigation) accounts for 82% of human-based water consumption and it is the primary reason why many of world's major natural water bodies are shrinking so rapidly. This issue is exacerbated by large-scale reallocations of irrigation water to other uses due to human population growth that is predicted will cause annual global losses of 350 million m^3 of food production in [1]. One of the visible impacts of irrigation water sustainability is the increasingly evident of irrigation water shortage during dry season in many areas in Indonesia.

Cropland sustainability issue related mainly to the declining trend of irrigated area. From 1950 to 1981, the world grain area expanded from 587 million to 732 million hectares due to the growth in irrigation. However, some of them were not ecologically sustainable and since then irrigated land has shrunk to 647 million hectares in 2002 for various reasons such as eroding soils, dustbowl forming, water shortages, deserts encroachment and even converted into other uses [1]. In Indonesia, it is estimated 2.5 million hectares of paddy fields has lost without an equivalent replacement for the last 20 years [2] and converted into housing (30%), industry or other crops for example palm oil (65%) and other uses (5%) [3].

With a relatively the same world's irrigated area but with population more than doubling, grainland per person drop by more than half from 1950 to 2000. In Indonesia, current average farms are only 0.5 hectare. Even worst, it is predicted in Egypt, Malaysia, and Rwanda, the grainland per person will be half the size of a tennis court in 2050 [1]. Millions of farmers today can be categorised as smallholders and effectively landless. These become a challenge to sustain irrigation.

Since, there is global imperative to make efficient use of irrigation water and land, irrigation must respond to serve an increasingly productive agriculture and must be managed at its best in order to utilise the natural resources efficiently, wisely, and cost effective. However, one of the biggest threats to irrigation in Indonesia is deferred maintenance of irrigation caused primarily by lack of adequate funding. It has created severe constraints on the performance that has resulted in low productive the use of water and land, which in turn threatens the sustainability of irrigation systems. Therefore, the challenge of irrigation is to improve the performance of the system which can lead to the increase of productivity of water and land, which in turn guarantee the sustainability of irrigation systems.

Improved water and land productivity in irrigation can be achieved through better asset management. At the moment, many water agencies see asset management as an alternative to improve the financial and service performance of facilities in irrigation system. In Indonesia, the government implements farmer participation approach in managing irrigation water and asset. This paper presents the efforts possible and steps should be taken to improve the irrigation system performance and develop an appropriate AMP that enable WUAs in rural Indonesia managing the assets of transferred irrigation system in a best/most cost-effective way in order to achieve sustainability goals.

2 Review of asset management plan for irrigation

Irrigation asset management are explained by a number of experts, one of which is as follows:

> "An integrated approach to improving the ability of an irrigation system to deliver water at a defined level of service in the most cost-effective manner" [4].

Asset Management Plan (AMP) helps irrigation authorities utilise and maintain the condition of its assets at the best possible way and be kept running at a good operating standard, provide a level of service that is consistent with cost-effectiveness and sustainability objectives, and improve the system performance. Broad goals of system performance improvement are to achieve improved irrigation efficiency and better crop yields, less canal damage from uncontrolled water levels, more efficient labour, improved social harmony and improved environment as a result of less diversion or better quality return flows.

Since the Government of Indonesia is adopting policy of transferring irrigation to farmers at the tertiary level, a Simplified AMP for transferred irrigation systems is a relevant and applicable procedure to be utilised. The procedure consists of activities of (a) assessing, monitoring, and regulating over time the condition of government-owned irrigation infrastructure; and (b) managing, operating, and maintaining of which has been transferred to WUAs and WUAFs. It involves process of stipulation of the standards by which performance will be measured and the desired level of service that requires communication between the irrigation authority and WUA. This is a mechanism for focusing the attention of WUAs and WUAFs on sustaining and enhancing the condition of the irrigation infrastructure [5]. Asset management in Indonesia context as suggested by IIS also should include the elements of needs based budgeting, irrigation service fee (ISF), turnover program, efficient operation and maintenance, programming and monitoring system, integrated basin water resources management, project benefit monitoring and evaluation and cost effective rehabilitation and modernisation system research study.

Eventually, AMP outcome is desired to meet requirements such as reliability, manageability, financial viability and physical sustainability and is also required to give effect to the equity, productivity and environmental. It should consider the constraints, priority of alternative strategies, and sources and realistic level of funding. A financial model is one of products of AMP that presents provisional investment program that consists of capital planning (20 years), budget planning (5 years), budget priorities (investment priorities, 5 years).

3 Methodology of developing asset management plan for sustainable irrigation

An AMP for sustainable future Indonesia irrigation systems was developed by through several stages and by utilising several methods that have been internationally accepted. Assessing system performance is a very first stage and major component of an AMP. It then followed by appraising the system performance shortfall and its causes, quantifying the causes of system performance shortfall (sustainability of the system) and seeking the corrective actions needed. The last stage is developing an applicable AMP and organisational adjustment needed that enable WUAs managing the system in a best-cost effective way. The process of developing a simple and cost-effective AMP for rural irrigation system in Indonesia is depicted in the flowchart as follow:

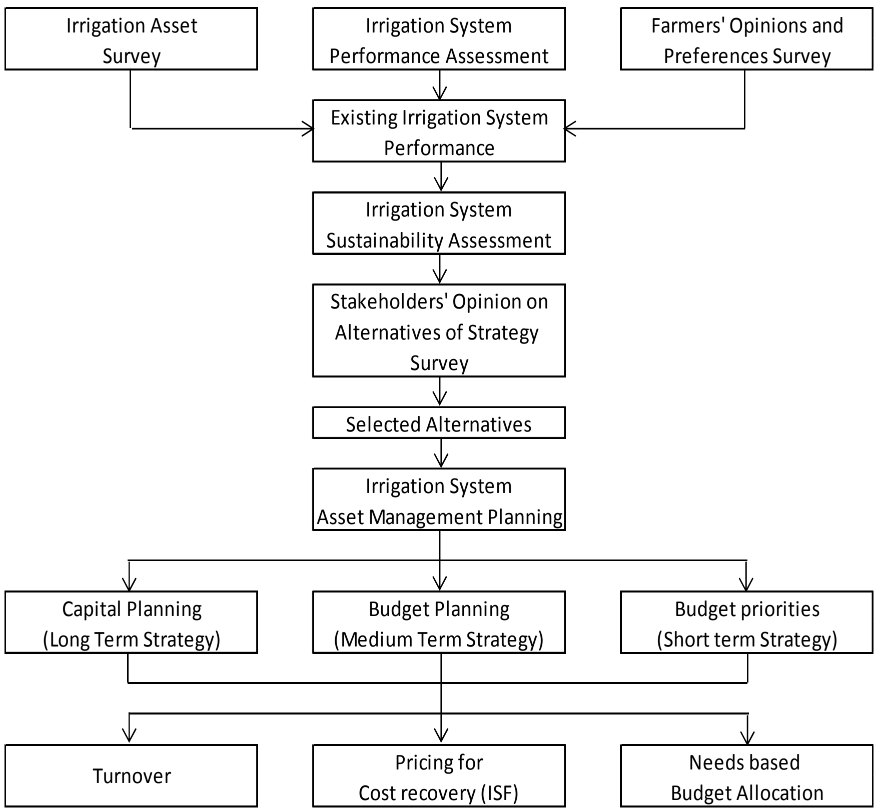

Figure 1: The stage of developing AMP.

The following figures illustrate the case study sites and the typical distribution of irrigation networks in an irrigation system in Indonesia.

Figure 2: The sites of irrigation systems of the Province of Lampung (courtesy of the Irrigation Authority, the Province of Lampung).

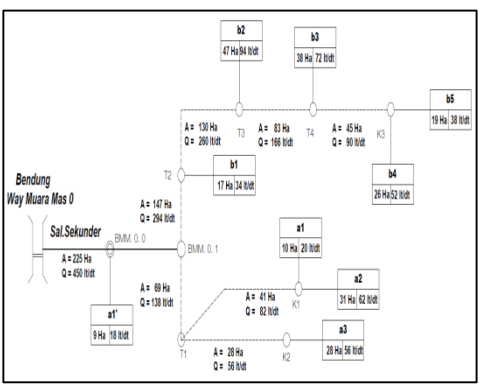

Figure 3: Way Muara Mas canals and field plots network (courtesy of the Irrigation Authority, the Province of Lampung).

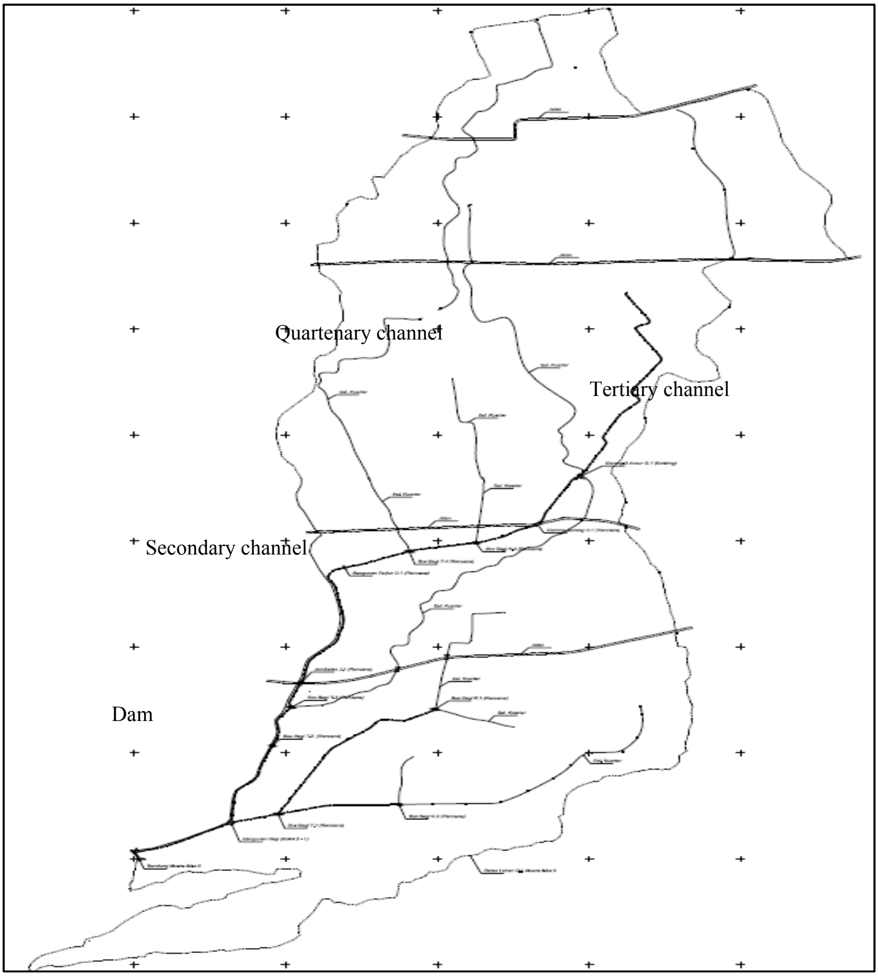

Figure 4: Way Muara Mas canals network (courtesy of the Irrigation Authority, the Province of Lampung).

This paper presents 11 irrigation systems (1 large, 3 medium and 9 small irrigation systems) as case studies that scattered throughout the Way Seputih and Way Sekampung River catchment area at the Province of Lampung, Indonesia.

4 Discussion

4.1 Performance of existing irrigation system in rural Indonesia

The first stage, assessing system performance, consists of performance assessment survey, opinion survey, and asset condition survey. The performance assessment survey was utilising the RAP developed by Dr. Charles Burt from the Irrigation Training and Research Center (ITRC) –

California Polytechnic State University, the asset condition survey was adapted the guideline developed by IIS – University of Southampton, and the opinion survey questionnaires was developed by taking into account aspects suggested by Abernethy *et al*. [6] and Creswell [7].

4.1.1 Farmers' opinions and preferences

Opinion survey of farmers' water user regarding issues that affect them closely on irrigation system, policy and management is aimed to obtain better insight into their wishes [8] and to capture their satisfactions, discourses, preferences, perceptions, beliefs, practices and knowledge [9] about irrigation services provided.

An easy and quick quantitative method was chosen since it enables to test and measure the opinions of large samples of the community in which there is probability of a high illiteracy rate, reliable to investigate variations of opinion according to possible determinant factors, easy to adjusted, and economical [5, 6].

The questionnaire was carefully designed by considering the aspects: as short as possible, simple close end-questions, and in local language [6] that is Bahasa Indonesia. It consists of 18 statements related parameters to irrigation and drainage services, asset condition, management practice, WUAs, and farmers' income. It is aimed to capture farmer's opinion and discourse on the current level of service, perception of differences in service levels before and after the project executed, expectation on the level of service in the future and willingness to bear consequences if the service level or infrastructure upgrade.

The population surveyed were farmers who came from 11 case studies irrigation systems and a stratified random sampling was utilised to representing farmers in the upstream, middle and downstream plot in the irrigation canals. The farmers that selected randomly interviewed based on semi-individual and semi-directive on–farm (on the village).

The following figures show some of the results from the Farmers' Opinion Survey:

Based on the survey, farmers are generally satisfied with the irrigation services provided by the government at the moment. Since most of these rural irrigation systems were generally developed in the Green Revolution Era of the 70s, farmers can see noticeable differences on their lives due to the development of these irrigation systems. Still, they expect the government to be able to provide better services and infrastructures. If the services and/or infrastructure up-graded, most farmers tend to add growing seasons rather than vary crops, half of them willing to pay higher ISF for better service, but most of them were only willing to participate in labor/manpower rather than to donate money for it.

4.1.2 Irrigation asset condition

The following field survey of asset condition was conducted to gather data about the current functional condition of existing irrigation systems and assets. The survey method adapts the procedures developed by IIS that differentiate between the general condition of an asset and its ability to perform its function (serviceabiliy). IIS also distinguish condition grades with good, fair, poor and

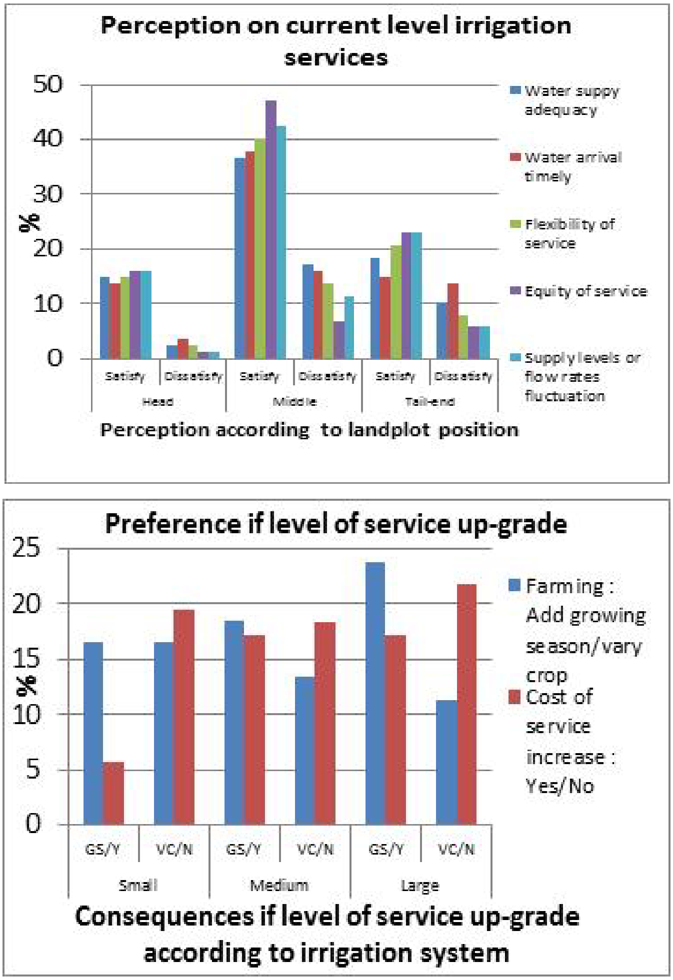

Figure 5: Farmers' opinion survey results.

bad; and serviceability grades through hydraulic and operation function with fully functional, minor functional shortcoming, seriously reduced functionality, and ceased to function. Assigning a grade to the condition of the assets will provide a quick guide to the condition of the assets. However, by measuring these two indicators separately, expenditure priorities are more likely to keep the asset functional rather than merely maintain their appearance [10].

In general, the asset condition assessment results indicate that the assets condition of the irrigation system under the central government authority is sufficient, the systems under the jurisdiction of the provincial government are less good, and the systems under the authority of local governments (district/*kabupaten*) are in poor condition. Variations in condition are due to the differences in the amount of routine O&M funding received from each authority.

In Lampung, the systems under the authority of central government receive routine O&M fund of Rp.135,000.00 (US$15.00) per hectare per year. Meanwhile the systems under the authority of the provincial government receive about Rp.80,000.00 (US$8.89) and the systems under the authority of local governments receive about Rp.40,000.00 (US$4.44). The amount of routine O&M funds for each province in Indonesia is not much different and in generally these amount of funds from year to year has not changed much. In addition to routine O&M fund, an irrigation system also receives funds for rehabilitation, improvement or up-grading the system but it is carried out in a non-routine project framework.

It is realised since 1990 that the cost of O&M (operation and maintenance) are inadequate and resulting in decreased performance of the irrigation network. Vermillion estimated that the average budgetary requirement for maintenance in Indonesia's public irrigation systems was $18-28/ha, compared with actual expenditures of $5-13/ha [11]. The current O&M funds of large irrigation system are approaching that requirement, thus it is clear that why the condition of large irrigation systems are reasonable, while medium small irrigation system is not.

4.1.3 The irrigation system performance

The performance of existing irrigation system in rural Indonesia was assessed using a method that has been accepted internationally, that is RAP process, relating to external performance indicators, internal process indicators, water balance indicators, financial indicators, agricultural indicators and environmental Indicators [12].

In summary, the performance assessment results shows that in general case study irrigation systems have low performance: efficiency of 65%, average field irrigation efficiency of 47.76%, average command area irrigation efficiency of 31.05%, average cost recovery ratio of 0.75, average maintenance cost to revenue ratio of 0.38, average revenue per cubic meter irrigation water of US$0.00431/m^3, average total MOM cost per meter cubic irrigation water of US$0.00282/m^3, and average output per unit water supply of US$0.24/m^3. This is an alarm that some actions should be taken to address these issues to improve irrigation performance and keep the sustainability of irrigation systems in the future.

4.2 Sustainability of future Indonesia irrigation system

The second stage, assessing the sustainability of irrigation systems, consists of appraising and quantifying the system performance shortfall and its causes, and seeking the corrective actions needed. The sustainability of existing irrigation systems were assessed by following the aspects of adaptive framework and methodology for improved TBL reporting by irrigation organisations developed by the Sustainability Challenge Project. The subsequent opinion survey then conducted to determine the stakeholders' preferences on the corrective actions priorities to improve sustainability of the systems.

4.2.1 TBL sustainability assessment

There is a very close relationship between an irrigation system's sustainability and the various aspects of its performance. According to Abernethy [13], sustainability can only be achieved if the resources that are necessary for the conduct of irrigated agriculture will continue to be available. The major resources that must be assembled and maintained are water, land, labour, energy and finance. A set of indicators sustainability issues that need to be address in particular system is based on specific indicators of performance, indicators of threats, and indicators of institutional strength.

The TBL reporting provides a means of showing the public that irrigated agriculture can be sustainable [14] and the Sustainability Challenge Project has developed an adaptive framework and methodology for improved TBL reporting by irrigation organisations (both rural and urban), which can be used to measure sustainability in complex system. The framework identifies the issues of concern related to environmental, economic and social (planet, profit and people) sustainability to stakeholders, identifies the objectives related to sustainability, and then addresses these objectives using selected indicators and performance measures [14].

The sustainability concerns of the case study irrigation systems as inferred from the results of the performance assessment are:

1. Profit: water balance, productivity and efficiency, asset sustainability, customer/farmers, staffs, business management (irrigation system management), financial sustainability and economic sustainability.
2. Planet: water uses efficiency, achieve high level of environmental performance in systems and basin level (minimise negative environmental impacts of irrigation, especially the long-term cumulative negative and consider the net effects of the system to environment), and social aspect of environmental (the environmental effects often impoverish tail-end farmers).
3. People: strengthen WUAs and WUAF technically, financially, and institutionally and legally (handover more responsibility on the farmers to care for the supply system and hand over of responsibility for the O&M irrigation infrastructure above the tertiary turnouts), achieved social capacity (users stake in irrigation system) and a benefit sharing/dividend reinvestment projects given to poor communities in the upper region who do not receive the benefits of irrigation to prevent them from deforesting the upper region (to stop sedimentation and flood in lower region).

The TBL sustainability assessment indicates the actions to be taken as suggested by Bruns and Helmi [15] are:

1. Modernising irrigation systems: (a) applying pressurised irrigation method and recirculate the irrigation water to improve irrigation efficiency, (b) improving channels condition and increasing the number of turnouts/offtakes to improve irrigation service and water distribution, and (c) expand the scope of irrigation service fee (ISF) by specifying water delivery service, install suitable measuring devices to implement ISF based on the volume of water

used, and raise the ISF to improve water use efficiency and to increase management, maintenance and operation (MOM) costs recoveries.
2. Improving irrigation system management, procedures, and communication by improving participatory in irrigation management: (a) diversifying agriculture and developing agricultural business, (b) expand the role of WUAs as business organisation/enterprises, and (c) turnover secondary level/larger system to WUAs.

A subsequent opinion survey was conducted to determine the stakeholders' preferences on the proposed actions above.

4.2.2 Weighing priorities of proposed approached of activities

In making choices, it is important to establish weightings or priorities for these approaches. It tested to the stakeholders of irrigation through opinion surveys to determine the ranking of the approaches that are most likely to be implemented. There are methods used to evaluate prioritisation of asset maintenance/renewal. However for these irrigation systems, the method used to weight the proposed activities was a Simple Pair Wise Comparison Matrix. Since this method simply confronted the decision makers to compares two alternative at a same time, it is a reliable and robust way of eliciting preferences from decision makers and weighting criteria [16].

Preferred activities obtained by weighting opinion on the proposed activities vary from irrigation authorities, consultants and farmers. In total, the top-three preferred activities are to (I) improve channel condition, (II) develop WUAs as a business organisation, (III) expand the scope of ISF, (IV) diversifying agriculture, (V) pressurized and recirculate irrigation system, and (VI) expand the scope of WUAs authority to a larger system. Thus, based on these preferred activities the AMP will be developed.

4.3 Asset management plan

The last stage was develop a simplified AMP model that enable WUAs in rural Indonesia manage the assets of transferred irrigation system in a best/most cost-effective and sustainable way based on the activities chosen from the previous stage. The three most important things that should be considered in developing the model are:

4.3.1 Participatory in irrigation

By 1980s, there was an increasing imperative to improve participation in irrigation management (PIM) in Indonesia and since then various regulations and projects have been launching to support farmers' PIM. At the moment, the government implemented the Participatory in Irrigation Sector Project (PISP) that facilitates WUAs to act as a business organisation to stimulate the rural economy. Bruns and Helmi found participatory had demonstrated some benefit, but the challenge for development of participatory irrigation management lies in instituting better approaches to perform the key process of equitably distributing water and maintaining irrigation system [15].

At tertiary and quarternary levels, financially autonomous WUAs are responsible on the operation, maintenance, renewal, finance, and management of irrigation. Tradition-based water arrangements such *Ulu-ulu* and *Ili-ili* are accommodated in WUAs which their assignment is aimed to improve the efficiency of irrigation water use at farm-level. Based on Farmers' opinion survey, most farmers think that WUA is effective to accommodate their needs and WUA performance is better than before the project implemented. They also recognise the effectiveness of WUA in conveying their interests to the government, and vice versa WUA become an extension of government officials to disseminate information to farmers more effectively. However, they hope WUA could improve their performance in the future.

4.3.2 Pricing for cost recovery (irrigation service fee)

Pricing water play a significant role in encouraging more equitable and productive use of water by farmers (efficiency), to fund operation and maintenance, and also can play a critical role in determining the levels of demand and supply and the amount of resources invested. There are variation in water pricing methods and many conflicting goals inherent to charging for water such as economic efficiency, cost recovery, revenue maximisation, regional equity, ability to pay, environmental cost avoidance, and demand management [17]. Vermillion and Johnson proposed on area, volume and output basis choices on order to establish a workable ISF rate [14].

In Australia, water utilities are required to recover the full cost of service in their rates. Unfortunately, in many irrigation systems around developing countries, water is provided as a free service or the pricing systems act as disincentives to efficient water use (do not support the most efficient use of scarce irrigation water). These countries have failed to make the necessary policy changes required to cost recovery of their irrigation system and water pricing often determined only by the amount needed to recover the cost of maintenance and operation of irrigation systems [19].

In Indonesia, ISF is established at tertiary level which is aimed to generate and allocate sufficient funds for use by WUAs to properly support tertiary O&M activities. However, since irrigation water is not a problem in wet season, water is only appreciated in the dry season (only few real dry periods). In dry season, water availability is an important factor that affects the level of services provided to the farmers. Unfortunately, it is unknown how much the actual volume of water that has been supplied to the landplots and difficult to measure the efficiency of water since the existing method measures the water flow rate instead of the volume. Therefore, ISF is established on seasonal basis according to the area irrigated, with no distinction between cropping seasons. Each WUA is able to decide on the charge to be levied on its member. In the province of Lampung, the rates are vary from 50 to 60 kg per ha (1.33 to 2.07% of their income based on 2009 unhulled rice selling price). Provision used to fund O&M costs at tertiary level varies between 20 to 40% of ISF collected. The rest is used to pay the WUA's board member, controllers of water distribution (*ulu-ulu* and *ili-ili*), administrative costs, and reserve fund.

Despite the small rate of ISF, most of the farmers remain poor because they only cultivate landplot of 0.5 hectare on average which only could generates monthly income of Rp1,000,000.00 (US$125.93). This amount only meets about half of their needs, to note if there is no disruption to harvest. No wonder the next generation of farmers see agricultural sector is no longer interesting and this can adversely affect the sustainability of irrigation.

Based on the Opinion Survey, generally farmers feel the current measurement of supply flow rate is fair and better than before the project implemented but they expect it could be up-graded to the more sophisticated system. They also feel the current irrigation water tariff is affordable, feel content with the current tariff, hope this tariff could last long, and feel the current tariff is better than before the implementation of the project.

4.3.3 Needs based budgeting

Since most irrigation and drainage systems are characterised by weak performance assessment framework, many agencies end up functioning on a contingency response basis – if something goes wrong it will get fixed, but until there is a crisis, no action is taken [20]. This is coupled by the fact that government funding is limited and the ISF collected from farmers is very small and not sufficient to fund the irrigation system. The average rehabilitation cost of the case study irrigation systems spent by the government through PISP was Rp1,800,304.15 (US$200.03)/ha.

By considering constraints and priority of alternative strategies, the Simplified-sustainable-and cost-effective AMP model developed which enable WUAs implement it dependently and easily consists of budget planning and 5 year investment priorities as follows:

1. Budget planning (5 years): routine MOM costs,
2. Short-term planning (investment priorities, 5 years): improve channels condition and network, and increasing the number of turnouts/offtakes to improve irrigation service and water distribution.

While for medium and long-term capital planning, the government involvement is a necessity:

3. Medium-term planning (capital planning, 10 years): install suitable measuring devices to implement ISF based on the volume of water used, raise the ISF to improve water use efficiency and to increase cost recoveries,
4. Long-term planning (capital planning, 20 years): implement pressurised irrigation method and recirculate the irrigation water to improve irrigation efficiency.

The efforts to modernise the system have to go hand in hand with the efforts to improve farmers' participation in irrigation management. It can be achieved through the activities of developing WUAs as business organizations, expand the scope of the ISF, implement agricultural diversification, and expand the authority/turnover secondary level/larger system to WUAs. These activities are also to be carried out in stages.

5 Summary of conclusions and recommendations

Through various programs, the government of Indonesia seeks to improve irrigation systems and accelerate community participation in the management of irrigation systems. As a result, farmers are mostly satisfied with the current service, eager to be involved in the government program for rural development, yet they hope there will be an improvement in irrigation service, infrastructures and management in the future. Despite those efforts taken by the government, this study found that:

1. The performance of most rural irrigation systems are still low (sections 4.1.1, 4.1.2 and 4.1.3), thus the sustainability of the systems in the future are in risk (section 4.2.1). Irrigation systems should improve its efficiency, productivity and independency in funding the systems to support the sustainability of the system in the future by taking the suggested corrective actions (section 4.2.2). It is recommended that:
2. The approaches to modernise irrigation system and improve the participatory in irrigation management have to be implemented in parallel (sections 4.2.2 and 4.3). Modernization of irrigation systems that requires big capital costs such as implementing pressurised irrigation with close channel (piping) are still less desirable (section 4.2.2).
3. ISF to be levied should encourage more efficient use of scarce irrigation water and could cover the cost recovery of their irrigation system. Therefore, it is a necessity to raise farmers' awareness about the value of water, water footprint and virtual water. Eventually, when the ISF is raised, farmers realise that these things is necessary. On the other hand, it is indispensable efforts to stimulate the rural economy so that farmers can afford such ISF (section 4.3).
4. The simplified-sustainable-and cost-effective AMP model developed which enables WUAs implement it easily and independently consists of only budget planning and 5 year investment priorities (section 4.3).

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