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The agricultural water resource management model in Lam Se Bai Irrigation Area, Amnat Charoen Province, Thailand

Chunsuparerk, D. *

The Regional Development Strategies Graduate School, Ubon Ratchathani Rajabhat University, Thailand.

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Abstract Upon encountering crisis from climatic and geographical influences in Lam Se Bai irrigation in Hua Taphan district, Amnat Charoen province particularly during summer and rainy season, the impacts of drought and flood are considered as persistent obstacles to the subsistence and economic security for domestic farmers. Regarding its consequence as a principal stakeholder of approximately 474 Acres in the affected area, this research was conducted to solve significant problems specified as follows; submerging floodplains, water deficiency, inefficient water management, negligent maintenance, inadequate water conservation, and limited knowledge in agricultural water management. The findings indicated that public participation was a prior influence, followed by water management, agricultural support, maintenance, and water conservation. These five elements enabled relevant sectors to unravel the management problems. Primarily, water management encompassed policy, measure, and management machinery improvement. The policy comprised of exploration, usage, and countermeasure. However, machinery progress required multi-cooperation, where efficacy was demanding. Integration process facilitated public to engage in planning, implementation, and evaluation. This allowed water users to promptly resolve unexpected situations. Agricultural support required collaboration to set action plans. The general strategies was centralized on drought and flooding. Canalization for agricultural purpose in seven drought areas has been constructed. During seasonal flooding, off-season and overtaken paddy field were developed to elongate to floods. These strategies enabled farmers to live with climate variability. Maintenance entailed the coordination between water users and regional irrigation office to distribute an applicable regulation and monitoring strategy, along with water conservation. Natural calamity and farming activities affected water quality. Organic farming and new theory agriculture practically conserved resource quality in the studied areas.

Keywords: Agricultural Support, Locals Integration, Participatory Management, Water Sustainability

Introduction

Modeling regional-scale water resource management for Lam Se Bai irrigation areas required a new paradigm to resolve the defect of water

* **Corresponding Author:** Chunsuparerk, D.; **Email:** dee@somite.co.th

management in three subdistricts; Sang Tho Noi, Chik Du, and Hua Taphan. The model was conducted with the aims centered on exploration of the existing water management problems in the 1st phase methodology and developed model testing via workshop in the 2nd phase methodology. This integrated model was available for the 7 forthcoming additional ditches with a total length of 20.15 kilometers that were expected to complete in 2018 (Regional Irrigation Office 7, 2014). However, the water-supply-oriented components such as maintenance, conservation, zoning, sustainable agricultural support, and limited comprehension were still in need (Regional Irrigation Office 7, 2014). Natural and community systems necessitated various intense complexity, particularly, when water demand and its quantity were inverse (Holland, 2012). To generate sustainability, the cost of learning and adapting consequence including the inheritance limited agriculturalists' action leading them to associate with familiar approaches, places and agents (Wilson, 2014). This implied the requirement for multiscale governance with the importance of collective learning through localized engineering and user participation (Maciel *et al*., 2014). The advantages of this model were to maximize settlement solution and community participation as well as to adapt with developed infrastructure (Abbot, 2013). Recent attention has more emphasized on public involvement as a mean for agricultural sustainability and integrated water resource management (Mitchell, 2014). The impacts of climate change, inefficient management, and geographical difficulties have been the most significant factors. The 2016 report from the Department of Local Administration of Amnat Charoen, a governing office responsible for promoting and supporting local administrative organization, showed that the majority of studied areas was floodplain with dispersive and collapsible soil so that the possibility to encounter floods and droughts were more frequent and resource needed better practical management. These problems led to a policy to increase infrastructure development and conservation efforts resulting in dissimilar uses for some locals (Brainard *et al*., 2017). An appropriate sustainable water resource management was a crucial response to aforementioned circumstance. This change slightly became complex since some new methods could not go well with farmers' familiar ways and practical sustainability was new for local administrations (Holland, 2014). Consequently, local community needed more advocating precautionary and conservation attitude for better practice (Voll and Voll, 2016).

The Lam Se Bai River is a left-hand branch from the Mun River and reconnects with the larger Mun River near Ubon Ratchathani. Most of sub-basin overlaps with 3 provinces; Amnat Charoen, Yasothon and Ubon Ratchathani (Floch and Molle, 2013).

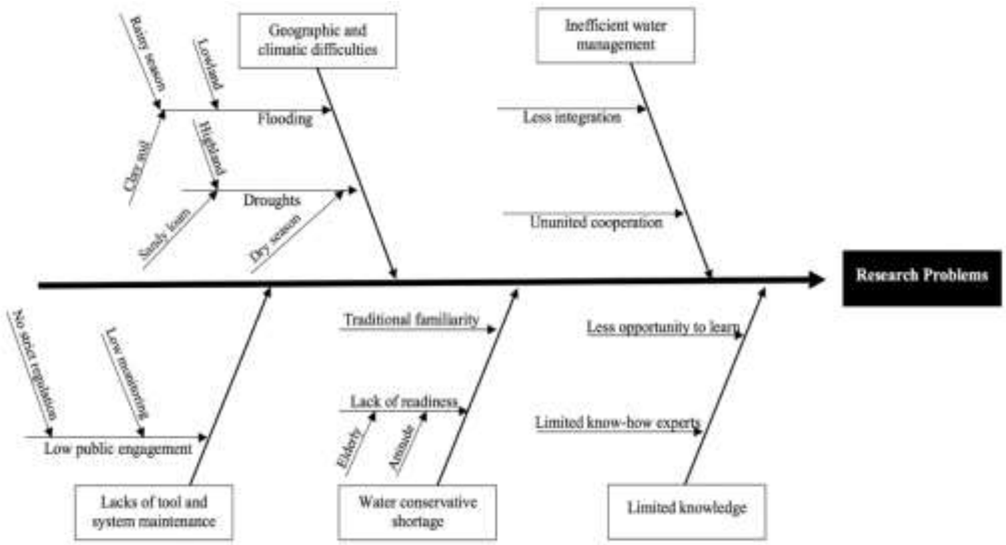

Figure 1. The developed Ishikawa Diagram of Kaoru Ishikawa in 1960 illustrating cause and effect of problems in Lam Se Bai

Participation and involvement from all parties to management evolution was an important aspect leading to sustainable solution for water resource management in Lam Se Bai irrigation areas (Casalino, 2014; Hribar *et al.*, 2015). Based on an exploration, locals happily provided their assistance in the research. Therefore, an opportunity to encourage participation in this study was feasible. Conversely, locals mostly had less chance to perform their willingness because government offices just occasionally asked them to join it. Legislation, planning and economic instruments were unavoidably crucial and it would be better with participation from people who involved in water management, especially from locals and community leaders (Grigg, 2014). Social learning and sustainable development of Kristjanson and others in 2014 indicated that societies could learn and adapt their behaviour to any changes if they could join learning and value the development. The study also stated that participatory learning - working together, exchanging, learning, and action – could lead to change in practice and create sustainability (Kristjanson *et al.*, 2014).

As for the water management, the theory of the maximization of utility was generally used to explain the response of the new technique (Edwards, 2013). National Sustainable Drought Management Policy**:** Expense for water pumping during dry season was significantly high. To minimize aforementioned cost, solar water pumping was an optional innovation (Bumataria and Patel, 2013). Another solution for droughts was a village water supply (Marks *et al*., 2014). Communities in the three sub-districts in Lam Se

Bai were agriculture-based livelihoods depended on many ways upon water resource but the recent investigation indicated that water quality was lacking. Long-term Flood Risk Management Policy: Flood risk management was dull although this policy should be one of the important procedure in the areas. Firstly, the move from flood defence to flood risk management has increased the prominence of flood warnings and public awareness as important tools for managing flood risk (Schindler and Hilborn, 2015). Hua Taphan and Chik Du got satisfied government support especially funding and community association. However, Sang Tho Noi was quite different because there were only several groups and the result from disaster was quite severer.

Lam Se Bai had an intense problem in tool and system maintenance. Compliance, ensuring that relevant rules, regulations, standards and laws were followed, was a key responsibility for agencies in addition to the implementation of natural resource programs through direct works or incentives (Sterner and Coria, 2013). This was where Lam Se Bai maintenance was lacking. Very few of farms in Lam Se Bai irrigation areas were organic. Organic farm could save higher quality of resources as well as conserve the water resource in the farm (Brainard *et al.*, 2017). With organic fertilizer, the residue was significantly diminished as it utilized only organic matter (Goldstein, 2018). Pests and weeds were controlled by cultural practices and organic chemicals made from herbs. New theory farming in the studied areas was more popular but not many farms using this method. This developed farming technique for small-scale farmers in Thailand was initiated by His Majesty the King of Thailand. The New Theory farming sustainably was the application of cultivating systems for farmers, particularly in small land use of north-eastern Thailand with scarce water resources. The measurement included rice paddy fields, a pond for water and fish, cash crops, cultivating trees, and a residential area. The land allocated to each area use could be flexible, regarding local resources. The most widely used ratio was 30:30:30:10. New Theory farming was an effective to save water in the context of resource value conservation (Niemmanee *et al*., 2015).

Materials and methods

The research was conducted in between March 2016 to 2017, focused on three sub-districts; Sang Tho Noi, Chik Du, and Hua Taphan in Amnat Charoen Province. The methodology relatively organized into 2 phases to explore the primary problems and to test the model.

Table 1. Timeline and places in this research

Step	Activity	Timeline	Accountability	Place
1	Literature review collection and landscape exploration	1 year	Researcher	Amnat Charoen and the related districts
2	Arranged meeting of 155 local farmers who directly used water from Lam Se Bai in Amnat Charoen province using stratified sampling, according to ration of subpopulation. The population scope was 259 water users and scoped down to 155, following the table of Krejcie and Morgan in 1970 – Sang Tho Noi: 45 farmers – Chik Du: 59 farmers – Hua Taphan: 51 farmers	1 day	Researcher, Survey team	Convention Hall in each subdistrict
3	In-Depth interview with village leaders and experts in water user association – 17 Village Leaders from 17 villages in 3 subdistricts; Sang Tho Noi, Chik Du, and Hua Taphan – 1 President of the Water User Association – 2 Vice Presidents of the Water User Association	1 week	Researcher, Survey team	Convention Hall in Hua Taphan District in Amnat Charoen
4	Model Development	1 week	Researcher	Home
5	Model Testing: Seminar and workshop with 30 agriculturalists and 10 experts to discuss with.	1 day	Researcher Survey team Experts in related firld	Convention Hall in Hua Taphan District in Amnat Charoen

Materials and methods

Participatory management was moderately new. The implementation of this model was donde to be useful in the areas. The issues in both phases were conducted including participatory theories with factors such as local participation, policy and measure, agricultural support, maintenance, conservation and the practice of the model. In the 1st phase, questionnaires and in-depth interview were conducted to explore problems and created the model.

To make it consistent, participants specifically was comprised of experts from related fields and local citizens engaged in a pilot project to explore the problems and the use of participatory management to assist with water resource management decision. In the 2nd phase, researcher was spent time in workshops to congregate ideas from local university experts in geology and hydrology. The workshop was arranged after the model created where 30 agriculturalists by inviting to test the model. Researcher was developed simulations from understanding toward stakeholder and locals concerns conveyed in the group meetings. After the comprehensive, they were asked to return to a group discussion with a simulated model to be evaluated by the group. This step scientifically followed the hypothesis generation and model assessment by Beall and Ford in 2011, as well as, embraced the simulation. The model was developed with the input and observation from workshop that elicited from discussion about the simulation results. This process was done to encourage the participants to explore plenty of questions frequently asked by local water users. It also helped with the exploration of individual participants models of water issues in the Lam Se Bai irrigation as well as the scientific uncertainty that was inherent to the system. The iterative process nature was done to help for promoting a shared vision of related problems and potential solutions via discussion and the process of model development. The interaction was provided an opportunity for technical discussion and brainstorm over technical elements of the model. For better illustration, two phases of procedure was done as follows:

Phase 1: Problems exploration with mixed research methodology

The process was applied to mix research methodology, qualitative and quantitative research. The quantitative method was used to explore existing problems water management in Lam Se Bai irrigation by focusing on five variables; public participation, water management, agricultural support, maintenance, and water conservation. To explore this scheme, researcher invited 155 agriculturalists for quantitative method, 17 village chiefs and 3 committees of local water user association for qualitative method to join in a participatory project to create a model that could be used for investigating possible scenarios. It was vital to emphasize that the basic problems in water resource management could enhance the validity to create accurate solutions which could be added in this model.

Process 1: Quantitative Method – 155 Questionnaires by Stratified Sampling

Process 2: Qualitative Method – 20 members of Hua Taphan Water User Association for In-depth interview by Purposive Sampling

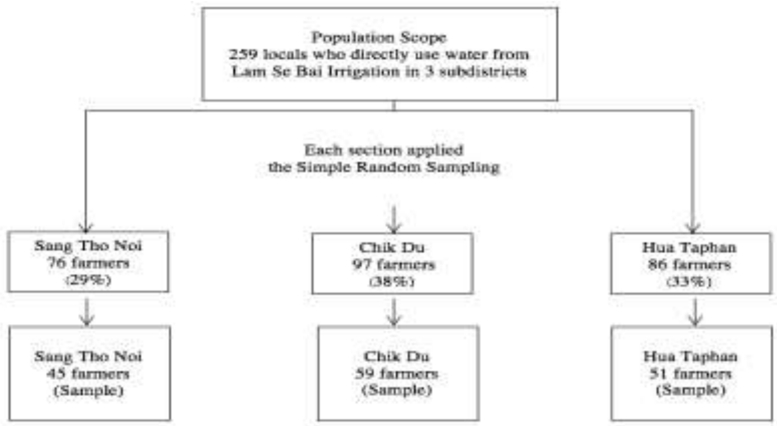

Figure 2. Process 1: Quantitative method – 155 questionnaires by Stratified Sampling

Phase 2: Model Testing

The Workshops for 30 Agriculturalists: this approach facilitated locals to attend and to encourage the water management entities to implement the Agricultural Water Resource Management Plan. Three-hour-workshop was held in the convention hall in Hua Taphan district. As noted before, researcher would take insights and information from the expert workshop and develop better practical model from workshop. This arrangement was reliable since 10 experts also involved in. Farmers required advices from those experts on the related issues, knowing that these experts were engaged in vetting increased confidence in the model. The first section of workshop began with a brief synopsis of agricultural water mission statement to ensure a long-term quality water supply for the Lam Se Bai irrigation through the development and implementation. This implied that the group was indeed centred on long-term sustainable management with a view that was far more comprehensive than others local discussions. This process circled around very specific localized topics. The first group exercise was a collaborative effort to create a Lam Se Bai irrigation timeline. The purpose of producing a timeline was to help participants viewing agricultural water resource management in the context of the greater model while acknowledging the collective awareness in the group and the geosocial context that originated the norm of communities.

Results

The results from qualitative and quantitative method would be aggregated and analysed using confirmatory factor analysis with correlation.

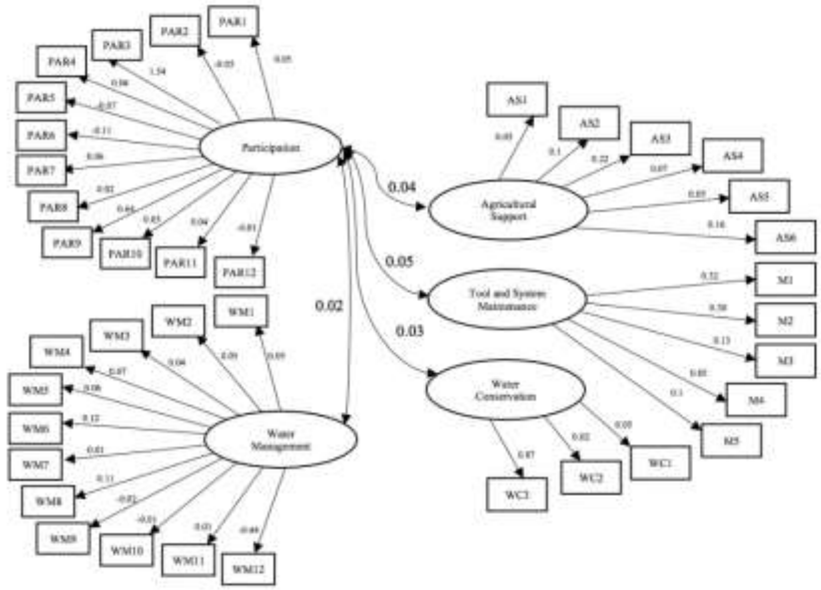

Figure 3. Confirmatory factor analysis indicated correlation and grouping

Phase 1: The result from problems exploration

According to the confirmatory factor analysis, there were significant correlations between participation and the other 4 components; water management (R =0.02, $P \leq 0.05$), agricultural support (R =0.04, $P \leq 0.05$), tool and system maintenance (R = 0.05,$P \leq 0.05$), and water conservation (R =0.03, $P \leq 0.05$). However, there were some contrasts inside each topics' component ($P \geq 0.05$) whilst the negative R represented the inverse correlation.

Phase 2: The result from model development

The initial process of this workshop set the tone for the project. One of the goals was to avoid possible deprecation. The timeline exercise was an important step for shifting this type of perceptions. The timeline reflected not only change in population and water resource management strategies but also distributions that were pertinent to the way communities had developed model. It also underlined that communities were in action to increase quality of life. These issues regularly had contingent on opposing sides of debates. The group also described possibility and other components included participation management, water management policy and measurement, agricultural support, tool and system maintenance, water conservation, and numerous other factors.

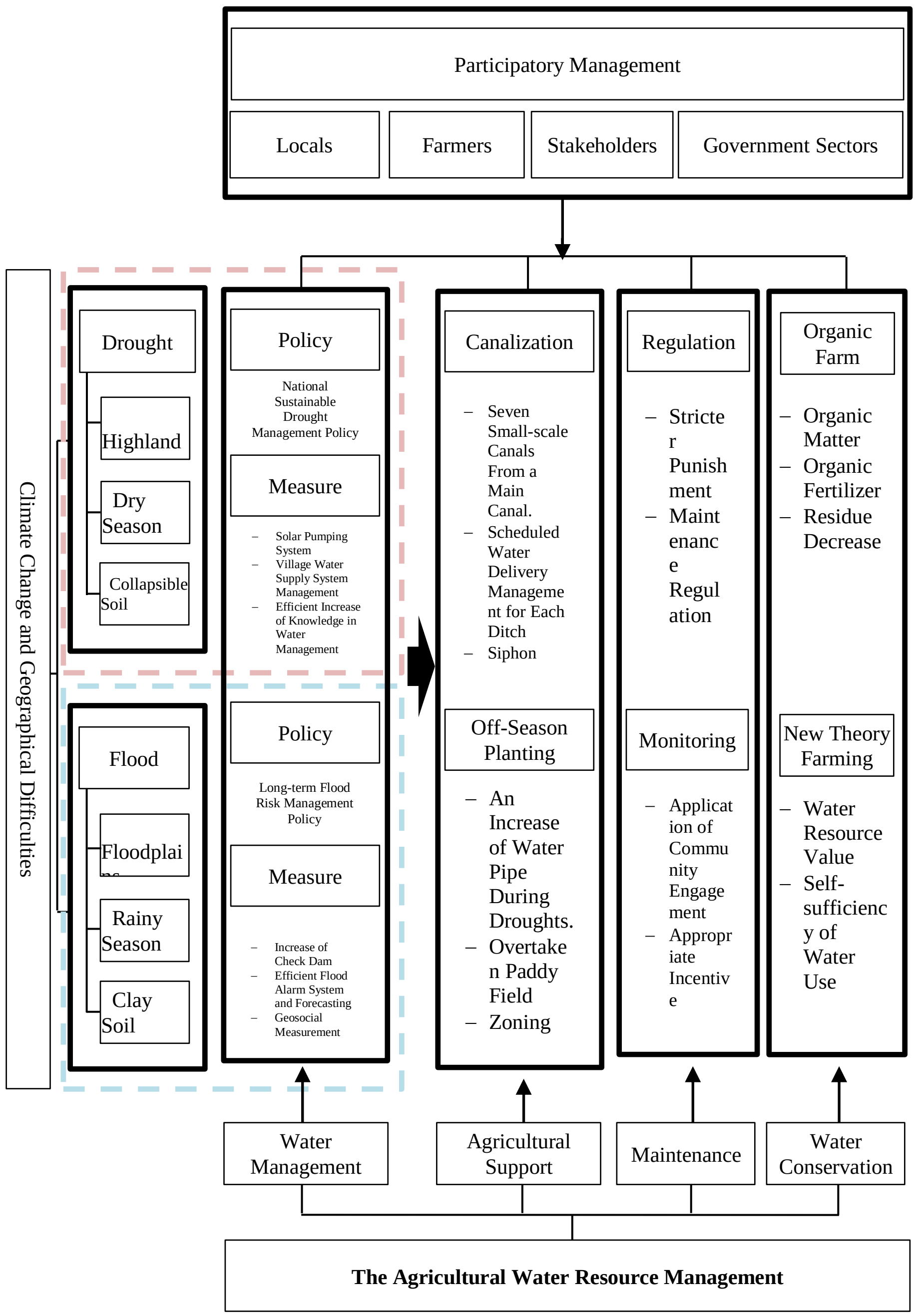

Figure 4. The agricultural water resource management model for Lam Se Bai irrigation areas

Discussion

Public participation in water resource management was significant because locals had the most experience living with those problems. As long as they could accurately learn and perceive usefulness, they could sustainably develop what they have taught by their own (Kristjanson *et al.*, 2014). This was where sustainability could be originally created. From the investigation of this research, participants' problems were lack of management knowledge and innovative cultivation method because of their familiarity and limited government funding (Grigg, 2014). This was the principal factor interfering development for civic leaders and locals in Lam Se Bai irrigation areas. Amnat Charoen is in the north-eastern Thailand where geosocial factors and traditional agricultural competence had an important role. Public participation developed in this research would focus not only on the intermittent activities, but also more on public participation in management process. The participation would begin from basic sustainable knowledge and public potency. To increase public participation, the development required both fund and intelligence of locality in order to encourage more possession and public consciousness from locals whilst government sectors would take more responsibility for agricultural innovation training and monitoring. This result supported Hribar and others' research in 2015 and Casalino's study in 2014. It could be assumed that the current problem in the studied areas was some limited influences toward participation, water management, agricultural support, maintenance, and water conservation. It might be because locals still troubled for lack of participatory support from government sectors, stakeholders, or village leaders. With respect to the response of the new techniques by Edwards in 2013, a new technique would be adopted if the utility obtained better performance than the old one. It could be assumed that the farmers' response to their situation was consistent with utility maximizing (Kousky, 2014; Rostamkalaei and Freel, 2014; Sterner and Coria, 2013). According to the agricultural support, farmers in Lam Se Bai irrigation areas truly required better water management solution as well as aforementioned funding. If the risk of disaster assistance had been previously planned by the recipients at planting time, the disaster assistance would have been affected on current production (Rostamkalaei and Freel, 2014). In consequence more supports from government were certainly required. Beneficiary pays was reasonable and enough for locals to guard the waterways (Sterner and Coria, 2013). To create more incentives, government would possibly agree to supply some land and water management activities that provided individual benefits to people who helped monitoring. This supported 2013 theory of Sterner and Coria. Management activities would be prioritized on the basis of the most public benefit for the least public cost. At this point, the subsidised public expenditure of a managing activity could be outstandingly reduced by rocking on a budget from the reserved. This would influence the level of priority for the action. Upfront and maintenance costs, waterway managers possibly collaborated with land owners and government agencies to declare standard of action. The cost of reestablishment and recovery of essential public assets after the disaster should be in accordance with the national agreement (Kousky, 2014). Organic matters and water conservation were feasible to set in the studied areas as stated in research of Brainard and others in 2017 and Goldstein in 2018 but farmers' readiness and their attitude regarding resource conservation might need further effort (Wilson, 2014). However, public participation was a key to encourage all aforementioned elements to sustainability in the areas via awareness enhancement.

After the research in Lam Se Bai irrigation areas, there were notable limitations to achieve these model goals. Exploration in studied area did not cover all population scope in the country since most of locals were in old age living with young residents. The majority of working-age population hunted jobs in other big cities (Regional Irrigation Office 7, 2014). Most of real inhabitants in Lam Se Bai irrigation areas were lack of proper knowledge in water resource management and the existing model was still in trouble of integration. With the difficulty of age issue, most farmers seemed too old to learn and accept new things, particularly the innovation. Thus, they had no energy to contribute sustainable farming since it needed to more workforces to reset some traditional way of farming. Agriculturalists in the studied areas mostly required the analytical result of their soil but the laboratory outcomes were still in waiting process. In other words, the current solution of soil solving was not succeeded. The scheduled water delivery via agricultural ditches was unpractical because every village needed water to be delivered in the early morning. The result of the poor management could not accomplish the daily water in a time they required. Moreover, the period in the survey experienced the shortage of time because each governing process imposed on timing procedure (Regional Irrigation Office 7, 2014). In addition, officers who should be on duty to provide related facts were terrified to provide the necessary information. As the infrastructure such as canalization was still in constructing process, the result after the whole-finished infrastructure was not completed. Although the model was created, the insufficiency of governmental budget and the delay of budget disbursement could not promptly influence the implementation. In other words, it was not possible to accomplish the problem solving on time when this research was published. However, this research was only a pilot study and the findings were required deeper and more critical investigation in the future.

Table 2. The summary of discussion

Theory	Result	Reasons
Integration of management with locals were crucial. (Kristjanson *et al*., 2014) (Mitchell, 2014).	Accepted	Locals engage in research exploration could assist water management decision better. (Hribar *et al.,* 2015) (Sayce *et al.,* 2013)
There were possibility to construct solar water pumping and sanitized village water. (Bumataria and Patel, 2013)	Accepted	It was possible to utilize the tool but it depended on government fund and locals' resource capability. (Rostamkalaei and Freel, 2014) (Sterner and Coria, 2013) (Kousky, 2014)
Agricultural support was useful to weaken hydrological damage. (Lark *et al.,* 2015)	Accepted	Zoning and canalization were crucial in the areas.
Incentives encouraged participatory management in maintenance. (Sterner and Coria, 2013)	Accepted	A number of authorities had compliance responsibilities to rules and agreements for the maintenance of waterways. All natural resource, locals and governors had a duty to ensure that the infrastructure were in good condition.
Agriculture with organic matters and resource conservation were possible to regulate in the studied areas. (Brainard *et al.*, 2017) (Goldstein, 2018)	Rejected for some cases	Some locals' attitudes might be difficult to change due to people's readiness and an ability to adopt new agricultural method. (Wilson, 2014)

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