FARM-LEVEL PARTICIPATION OF A NOVEL WATER SAVING EDUCATION MODEL TO IMPROVE WATER USE EFFICIENCY AND IRRIGATION SUSTAINABILITY

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ABSTRACT

The behavioral and attitudinal change towards sustainable resources utilization is a daunting challenge to the management of agricultural water conservation. The free-of-charge policy on agricultural water use in Korea hinders the farmers' perception of water saving despite the prevailing scarcity of water resources and incessant drought periods. This study addresses farmers' behavioral water conservation attitude using a novel participatory farm level-based water saving education (WSE) model on agricultural water management techniques and the need to conserve finite water resources in the fields. The developed model was based on farmers' participation in agricultural water use and irrigation management at the farm level, which consists of three stages: understanding, application, and practice. The model was applied in eight selected agriculture-based villages in Korea after which a follow-up survey was conducted on participating farmers to investigate their behavior and attitude regarding water saving and the willingness to replicate water saving practices in the fields.

The findings showed that prior to model implementation, a significant lack of water saving attitude was reported among 51.1% of the paricipating farmers. However, 91% of the farmers had changed their perception on the need for water-saving after the WSE, of which 75% reportedly experienced water shortage, and 62% experienced water conflict due to water scarcity and droughts in the past. Moreover, 97% of the water resources managers agreed to the necessity for WSE training. This study shows that WSE model could be a valuable tool for policy implementation concerning the effective agricultural water conservation, precisely at the farm level to improve water use efficiency and prevent impending water conflict among the water users.

Keywords: Farmers' education, water use efficiency, water conservation, irrigation sustainability

1. INTRODUCTION

Recentl threatening issues to the survival of humanity. The Sustainable Development Goals (SDGs) released by the United Nations highlight the role of sustainable agriculture as compared to the Millenium Development Goals (MDGs). In recognizing that the role of agriculture is related to hunger, food and water security, and climate change; striving to implement it with various goals in the field of international development cooperation in order to preserve a sustainable environment is very crucial (United Nations, 2015). The United Nations report predicts that by 2030, the earth will witness greenhouse gas emissions surge which could lead global water shortage (UN Environment, 2018). Moreover, Korea is categorized as water-stressed by the United Nations (UN Water, 2018), and the Intergovernmental Panel on Climate

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Change (IPCC) predicted that the average annual temperature on the Korean Penninsula would rise by 2.4 °C in 2050 making it become a subtropical climate (MOE Moldova & UNEP, 2010).

Currently, the effect of climate change has led to severe and persistent droughts, and consequently, farmers are constantly experiencing inadequate water supplies and damages on their farms (Nam et al., 2015). Of the 75.3 billion m^3 of available freshwater resources in Korea, 33.3 billion m^3 are used as domestic, industrial, and agricultural water, with 48% of it being used as agricultural water (Choi et al., 2017). However, the constant changes in hydrologic events and deficit in precipitation leading to a significant decrease in water availability has continuously altered the allocation ratios in which agricultural water use is the most affected of the sectors (Nam et al., 2015; KSIS, 2018). It is expected that further impact of climate change on the water resources as projected will further threaten water availability in the agricultural sector as the water demand continues to increase (Koutroulis et al., 2013). To avert the scenario of non availability of agricultural water in the future, it is important to institute appropriate measures to counter the effect of drought due to climate change through a system of sustainable water saving management approach.

Considering this fact, various studies have been carried out on the impact and measures to address the issues of water scarcity in the face of climate change and food production (Zhuet al., 2015; Masipa, 2017; Holmes et al., 2017). Among these sudies, the prominent proffered solution was adaptation policy for agrictural water management while the need to strenthen the storage capacities of water structures was also raised (Holmes et al., 2017). In line with this approach, adaptation strategy under the National Drought Management Framework; comprising of prevention, preparedness, response and recovery; was employed by Korean government in response to the 2014 -2015 drought in the country (Hong et al., 2016). Although the severity of the drought was reportedly addressed through water rationing and restriction on agricultural water use from numbers of water storage structures (Hong et al., 2016), however, this approach fall short in offering lasting solution to increasing frequency and intensity of drought most especially in agricultural sector that consumes the large percentage of water resources (Choi et al., 2017).

To address this, farmers' water saving is required as the critical measure to improve farm-level water use efficiency through a sustainable irrigation development. Moreover, Rezadoost & Allahyari (2014) re-emphasized the necessity of irrigation management training for farmers as one of the successful ways of agricultural water management. The study aimed to develop a participatory farm-level water saving model, for the overall objective of imbibing water-savings attitude in farmers to ensure water use efficiency and sustainability of agricultural water against the potential severity of current and future drought.

2. MATERIALS AND METHOD

2.1 Water Saving Education Model

There are two main stages of the methodology used in this study. The first stage involves the application of WSE, and the second stage was based on the assessment of the model application. Both farmers and water resources managers were involved in both the training and asseement of WSE. Farmers were trained and assessed on their change of perception and behavioral attitude towards agricultural water management under water savings and sustainable irrigation water use while the water resources managers drawn from Korean Rural Community Corporation (KRC) were educated on the maintenance of water irrigation structure, and tranferring of WSE to farmers, and their assessment was based on the necessity of the WSE

training. The model framework for the implementation of the two methodology stages is presented in Figure 1.

Items	Processes of water saving education model		
Education Contents	Stage Ⅰ Understanding	Stage Ⅱ Application	Stage Ⅲ Practice
	Water Movie Water game Discussion	Water loss A. Water save A. Discussion	Field inspection Field practice Improvement
Education Tool	Flash moving picture, Action learning	Water saving simulator	Field appication for water saving
Assessment	Survey	Survey	Survey

Figure 1. Framework for the education water saving model

2.2 Participations

The total number of 231 farmers and 322 water resources managers participated in this study under the project “Development of Water Saving Education.” The farmers were randomly selected from eight villages, one village in each of the 8 provinces across the country. Farmers in the selected villages are actively involved in farming activities and they have potential to adopt WSE training. The selection was carried out by the Korean Rural Community Corporation (KRC), a governmental agency in charge of agricultural water management. Similarly, the water resources personnel were selected from four regions; Gyeonggi, Kangwon, Chuncheong, Honam, Gyeongsang, and Jeju, of KRC offices.

2.3 Application Process Of WSE Model

During the first stage, there are three phases of applications; understanding, application, and practice; with distinct education tools and procedures. The themes of the value of water, water supply system and utilization, factors influencing water scarcity such as climate change, drought, and the consequence of water shortage including water conflicts, low supply of agricultural water were enunciated in the first phase as “understanding phase.” Flash videos, pictures, and action learning were employed as education tools which were followed by group discussion and presentation during this phase (Figure 2). The second phase, tagged as the application phase as shown in Figure 3, involves simulations of water loss and water saving related behaviors under drought scenarios. The knowledge gained through the understanding phase of the model in conjunction with group discussion was applied in the application phase. Further, water distribution games were used to practise water conservation through team work. The last step of the model application known as practice phase was used to identify the causes of water loss on the field and to draw out appropriate method for water saving in the field unit (Figure 4).

Figure 2. Understanding phase of model application

Figure 3. Application phase of model application

Figure 4. Practice phase of model application

2.4 Assessment Of WSE Model

A structured questionnaire was used to assess the level of change in the perception of farmers towards water saving after the education training, and also the necessity of the WSE training and its effective implementation were considered from the participants of water resources personnel of KRC. The questionnaire captured the necessary information about farmers and water resources managers involved on the factors that can enhance change of perception and the necessity of water saving in the field. The assessment only involved both farmers and personnel that completed the WSE program. The assessment of the WSE was based on variable factors including farmers' experiences on the water crisis and droughts, perceived causes of water loss in the fields, water management, interactions among the farmers for solutions on water-related problems, and the influence of WSE had on the participating farmers. The demographic variables including gender, age, farming year experience, farm size, and education and career level of the water resources managers were also considered. The necessity for WSE and water user association were further accessed among both the farmers and the water resources personnel.

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

Characteristics of both farmers and water manager personnel that participated and completed the WSE are shown in Table 1. Farmers characteristics indicated that majority of the participants are male (74.5%) and 69.7% are 60 years and older, reflecting the male domination in farming activities and the aging rural population of the Korean farmers. On the contrary, about 78% of the water manager personnel who participated in the training were below 50 years of age while the male population accounted for 87%. The youthfulness of the participated water managers is significantly essential to achieving the long term transfer of WSE model among the farmers.

Table 1: Descriptive statistics of participants' characteristics

Characteristics	Groups	Response Rate (%)	Characteristics	Groups	Response Rate (%)
Age	20~ 39	5.2	Gender	Male	74.5
	40~ 59	23.1		Female	25.5
	60>	69.7	Farming experience (years)	< 5	9.1
Farm size (ha)	< 1	26.8		5~10	4.7
	1~3.3	41.1		10~20	8.2
	3.3~6.6	21.6		20~30	12.1
	6.6~13.2	6.5		30~40	27.2
	13.2 ~19.8	2.2		40>	38.8

In term of experience, majority of the farmers are highly experienced with over 65% had more than 30 years of farming experience.. On the average, majority of the farmers of about 68% operate on field sizes up to 3.3 ha and grow paddy.

The distribution of water manager personnel showed that a considerable percentage (52%) are on 6th-grade position with 51% had 10 to 30 years of career experience. It is worth to note that despite the participant personnel's longtime career experience in water resources and irrigation infrastructural management, they had not engaged in WSE that could have afforded them the opportunity to transfer such training to farmers

on the water saving in the field with the aim to ensuring improved water use efficiency and irrigation sustainability.

3.2 Farmers Perception On Water Saving

The responses of farmers on their past experiences on water saving attitude are diverse. The results showed that about 49% of the farmers agreed to have been wasteful in their attitude towards agricultural water use; meanwhile, slightly above average numbers of farmers (57.6%) attributed the cause of water loss to aged channel with only 29% accepted that poor water management by farmers is responsible for water loss (Table 2). Similarly, while considerable numbers of farmers had experienced both water shortage challenges (74.9%) and water conflict (61.9%), mainly owing to scarcity of water resources during their long term farming experiences, majority of them reported that they relied on water resources personnel of KRC for solution, whereas about 27.3% were able to manage the scarcity on their own (Table 2). The results on varied opinions of farmers on water saving show that 45% of the farmers believed that agricultural water saving could be achieved at farm scale management level, and only 20.3% opined that addressing the faulty and aged water channels is the primary way through which the farmers can achieve significant water savings. However, a few numbers of farmers (6.5%) are of the opinion that joining the water users association (WUA) can stimulate the water saving attitude in farmers and about 28.1% of the farmers agreed that combining the farm scale management, repairing of damaged irrigation structures, and formation of WUA can provide solution to the attitudinal change of farmers towards water savings. About 46% of the farmers expressed their desire to join WUA to engage in campaign and implementation of water savings at their various regions and provinces.

In Korea, there was no charged fee on agricultural water use, notably on the groundwater extraction for irrigation water use (OECD, 2018), despite the increasing demand and general scarcity of freshwater water resources (Nam et al., 2015); hence the farmers result to unsustainable use of agricultural water use. Recently, the allocation of water resources to the agricultural sector has continued to decline from 47% allocation in 2007 to the present 41% allocation (KSIS, 2018). The perception of farmers on water saving has a very long way to go to ensuring irrigation sustainability for food production. In fact, the continuous reoccurring water scarcity and drought periods have negatively impacted on yield production and food prices (Nam et al., 2015). The WSE has shown to be an alternative way of ensuring farmers' change of perception and imbue water savings attitude in them.

Table 2: Results of farmers' perception on agricultural water saving

Questions	List of Answers	Response (%)
1) Do you think you are currently using enough water to farm?	① Yes	54.5
	② No	45.5
2) Are you satisfied with the current management of agricultural water by KRC or local government authority?	① Yes	73.2
	② No	26.8
3) Have you ever thought you were using more water than you need for farming?	① Yes	51.1
	② No	48.9
4) In Korea, agricultural water losses are high, what do you think is the biggest cause of agricultural water losses?	① Aged channel	57.6
	② Poor water management of farmers	29.4
	③ Illegal water-intake	13.0
5) Recently, have you experienced any water shortages in farming?	① Yes	74.9
	② No	25.1
5-1) If you have experienced, which time you experienced water shortages in farming?	① Transplanting	55.0
	② Growing	32.5
	③ Harvest	11.3
	④ Others	1.2
5-2) That time, how did you solve the shortage of water in the farm?	① KRC	72.3
	② Personally	27.3
5-3) Have you experienced any disputes among residents due to lack of water for farming?	① Yes	61.9
	② No	38.1
6) Do you agree with the necessity of water saving or conservation in agriculture?	① Yes	87.0
	② No	13.0
7) What do you think farmers can do to save agricultural water?	① Farm scale manage	45.0
	② Channel manage	20.3
	③ Join WUA	6.5
	④ All	28.1
8) How well do you think drainage gates in rice paddies management generally doing?	① Very well	26.4
	② Normally	49.4
	③ Never	24.2
9) Would you be willing to join as a member of the association of water use?	① Yes	53.7
	② No	46.3

3.3 Opinion Of Water Resources Manager On WSE And Farmers' Water Savings Attitude

In order to ensure the sustainability and widespread of WSE, the water resources personnel were involved in the WSE training and after which an assessment was conducted. The involvement of water resources personnel of KRC is essential considering the aging population of the Korean farmers. The phasing out of the current aging farmers would require the training of the new entrants of farmers on the water saving and management skills which can only be effectively carried out by the personnel in charge of water resources management. The survey result showed that the majority of the water resources personnel of KRC engaged in the WSE are experienced in water management or are currently in charge of water resources management (91%), while 89% of them reported to have experienced water shortage or scarcity (Table 3), bearing in mind their long term experience in water resources management.

The assessment conducted to assert the real water savings attitude of the farmers, the necessity of WSE and its sustainability reveal that farmers are indeed poor with water resources management. Moreover, about 82% of the water resources personnel agreed that they communicate with the farmers concerning the use of agricultural water resources and its management. Majority of the water management personnel attested to the nonchalant attitude of the farmers on water savings (49%). However, about 44% agreed that aged irrigation structures contribute a significant portion of water loss in the field.

Table 3: Water managers' opinion on agricultural water conservation

Questions	List of Answers	Response Rate (%)
Causes of water loss in the fields	① Aged channel	44
	② Management of water gate	49
	③ Illegal water-intake	3
	④ Others	4
Necessity of farmers' water saving education	① Yes	97
	② No	3
Required practice for farmers' water saving and conservation	① Water price quotations	60
	② Join WUA	21
	③ Normal	13

The water resources managers of KRC personnel are of the opinion that the management of agricultural water use by farmers is quite tasking due to their different perspective of causes and management of agricultural water in the field. They attributed the majority of the problem of water resources management to farmers' insincere complaint and their lack of water saving attitude rather than the water scarcity due to natural phenomena including drought-induced scarcity. The biggest identified problem of water resources management by KRC personnel is excessive water loss and poor management of water use at the irrigation entry gate by the concerned farmers. Consequently, their recommendations on the necessity of WSE for farmers is quite high (97%), especially after they were engaged in the train the trainer part of the WSE program. Notwithstanding the implementation of WSE, the opinion poll results showed that the best alternative way to ensure the compliance of on-site water conservation by farmers is the introduction of the water usage fee. The majority of the water managers are in support of the water price quotation for the

water use (60%); however, about 21% of them believed that establishing farmers' irrigation club or irrigation water user association can facilitate agricultural water conservations among the farmers.

Further, the three components of the WSE model; understanding, application, and practice were evaluated based on the water managers' opinions on their relative importance to potentially influence the farmers' perception on water saving attitude. The results of the evaluation showed that the understanding phase of the WSE ranked 43%, followed by the practice stage (40%) while the application phase was ranked least (17%). The relatively high ranked understanding phase was as a result of the water resources personnel opinion that farmers lack the understanding of water scarcity, and there is a need for proper orientation to correct their misconception and at the same time imbue the practice of water conservation skills in them. However, only 61% of the personnel are confident enough, after the trainer training program, to directly engage the farmers in WSE on the field. The primary reason cited was the inadequate human resources considering the farmer-personnel ratio in the country. However, about 16% of the personnel opined that more trainer training should be conducted to enhance the confidence level of the participants. Nevertheless, the majority of the personnel (87%) were quite satisfied with the WSE training and 93% of them gave a good recommendation for the overall assessment of the WSE trainer training.

4. CONCLUSIONS

The aim of this study was to develop a WSE model for farmers and water resources managers on agricultural water savings in response to the government policies on the sustainability of water resources utilization under the national drought management framework. The results show that the three basic components of the WSE model; understanding, application, and practice using hands-on resources have significant improvement on farmers' change of perception on water resources savings. Similarly, the results of the model assessment by the water resources manager reveal the need and necessity of both the WSE training program for both farmers and water resources managers. Moreover, in Korea, the water resources manager of the KRC are primarily involved in the water resources management and they have close contact with the farmers. Overall, this study provides strong valuable tools for policy implementation concerning the effective agricultural water savings and conservation, precisely at the farm level to improve water use efficiency and prevent impending water conflict among the water users.

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