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Full Length Research Paper

Prospects and challenges of management of smallholders' Wovwe Rice Irrigation Scheme in Malawi through participatory approach

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The concept of participatory approach in irrigation management was adopted in Malawi in the mid 1990s, but fully implemented in early 2000. This research was designed to analyze the challenges and benefits which Water User Associations (WUAs) encountered during implementation of irrigation projects using Wovwe Water User Association (WWUA) as a case study. The study thus examined the legal framework of WUAs in Malawi, their performance in water distribution, operation and maintenance, farmers' participation in WUA activities and how gender is addressed. Data was collected through questionnaires, which were administered to 290 farmers distributed in 15 blocks each comprising of about 20 to 25 ha of irrigated land. Qualitative information was also obtained through focus group discussions with farmers, and by interviewing officials of Water User Associations and those of the Irrigation Department in the Ministry of Irrigation and Water Development. Information sought included a wide range of issues including management of WUAs, participation of the farmers in WUA activities and women participation in decision making processes. The results indicated that 86.6% of the farmers are aware of the important by-laws of the Association, out of which 77% were satisfied. In spite of farmers` satisfaction, the constitution of the association is not effectively reinforced and followed. Water distribution is rotational and on supply-driven criteria. However, inefficiency of water use both on farm and in conveyance system was observed. Gender composition in key decision making positions is appalling with no women representation in the current WUA executive committee. The farmers have developed sense of ownership of the Association, but it was observed that limited financial resources, lack of technical and managerial skills and financial imprudence by the Association`s executive were the major challenges that derail WUA`s operations.

Key words: Community participation, irrigation management transfer, participatory approach, Water User Associations (WUAs), water resource management.

INTRODUCTION

Irrigated agriculture contributes significantly towards socio-economic development of the rural communities. It is estimated that about 40% of the world's food crops are produced by irrigated agriculture, which is significant to

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the food supply and to farmers' incomes (Peter, 2004). In accordance with International Water Management Institute (IWMI) (2007), African countries, especially Sub-Saharan Africa, have demonstrated commitment in investment, development and management of irrigated agriculture as a contribution to economic growth and food security. However, increased cost of irrigation development and management and international calls for implementation of effective and efficient water management practices has obligated developing countries to adopt participatory approaches in its irrigation schemes, which is conceived as the thrust area in effective irrigation management. This approach includes involving and associating farmers in planning, designing operation, maintenance, financing, decision making, monitoring, evaluation of the irrigation system and sharing responsibility in management of canal irrigation systems (Peter, 2004; Sushanta, 2007; Gondwe, 2008).

At a global level, the transfer of ownership and management of irrigation schemes to the Water User Associations (WUAs) or non-governmental organizations (NGOs) constituted the major irrigation reform since the mid-1980s (Shah et al., 2002). In accordance with Belsare (2001), there is a general acceptance all over the world that farmers through WUAs manage and operate irrigation systems, regulate and distribute water more efficiently among users. WUAs are used for irrigation management in more than 60 countries around the world (International Network on Participatory Irrigation Management (INPIM) and International Commission on Irrigation and Drainage (ICID), 2007; Belsare, 2001).

Management and development of irrigation schemes in Malawi after post-colonial era and before the new winds of policy changes that led to the establishment of Water User Associations was largely controlled by the government. Since the early 1980s, State run schemes have experienced several problems that have led to a substantial decline of the crop productivity and the state nearly stopped managing the schemes (Gondwe, 2008). The result was that most of them were in a state of inactivity with dilapidated infrastructure (Mulwafu and Nkhoma, 2003), which caused inequality in allocation and distribution of water, retarded water conveyance and increased water losses due to seepage in the broken canals and overflowing in canals. It was generally accepted that the State could no longer efficiently manage irrigation schemes alone, which led to irrigation policy reform. The introduction of water and irrigation policies gives farmers greater participation in management of the irrigation schemes, which is expected to improve efficiency of water distribution and crop productivity.

In recent years, the Government of Malawi has instituted a new irrigation policy, which has significantly departed from the past emphasis on costly government-supported smallholder irrigation schemes to participatory approach (Ferguson and Mulwafu, 2005). The new policies provide for stakeholder participation in the management of irrigation schemes, and the transferring of entire management into the hands of the beneficiary farmers. Although some aspects of Irrigation Management Transfer were adopted in the mid-1990s, it was not until 2000 that more fundamental measures were taken towards implementation (Ferguson and Mulwafu, 2005). By 2008, eleven Water User Associations were formed, Wovwe inclusive, under Smallholder Flood Plain Development Program (SFPDP) with funding from the International Fund for Agricultural Development (IFAD). Participatory approach in Malawi is implemented through Irrigation Management Transfer (IMT) that entails the formal handing over of control or management functions from Department of Irrigation (DoI) to Water Users' Associations (WUAs), which is a community-based organization owned, controlled and operated by user members for their benefits in improving water delivery, water use and other organizational efforts for increasing their production possibilities (Abou-Seida, 2001). Participatory approach encourages community partnerships with the government, builds community ownership of irrigation schemes and permits the communities to take on responsibility of maintenance and operation of their systems, as well as reduces the government expenditure on rehabilitation of irrigation systems (Cornwall, 2001).

It is the objective of this study to analyze the constraints and benefits of Water User Association (WUA) to a sustainable irrigation water management using Wovwe Water User's Association (WWUA) as a case in focus. The specific objectives of this study were to determine effectiveness of WUA in management of operation and maintenance of the project, assess participation of the farmers in WUA activities and investigate how gender issues are addressed in the Water User Association in operation and maintenance as well as decision making processes.

MATERIALS AND METHODS

Description of Wovwe rice irrigation scheme

Wovwe Rice Irrigation Scheme is located in Karonga district, one of the six districts in the northern region of Malawi (Figure 1). Karonga district covers an area of 3,355 km^2 with a population of 250,775 with intercensal annual growth rate of 3.3%, which is above the national intercensal annual growth of 2.8% (National Statistics Office (NSO), 2008). The population density of Karonga district has increased dramatically from 44 people/km^2 in 1987 to 58 and 80 people/km^2 in 1998 and 2008, respectively (NSO, 2008). The district is hot and dry from September to December, rainy from January to May, and cool and dry from June to August (Gondwe, 2008). There are several rivers, running through the district from the Matipa Complex Forest and Nyika Highlands to the west, which include Kibwe River, North Rukuru River, Lufira River, Remero River and Wovwe River. Songwe River forms an international boundary between Kyela district in Tanzania and Karonga district in Malawi. The population consists primarily of Tumbuka and Nkhonde

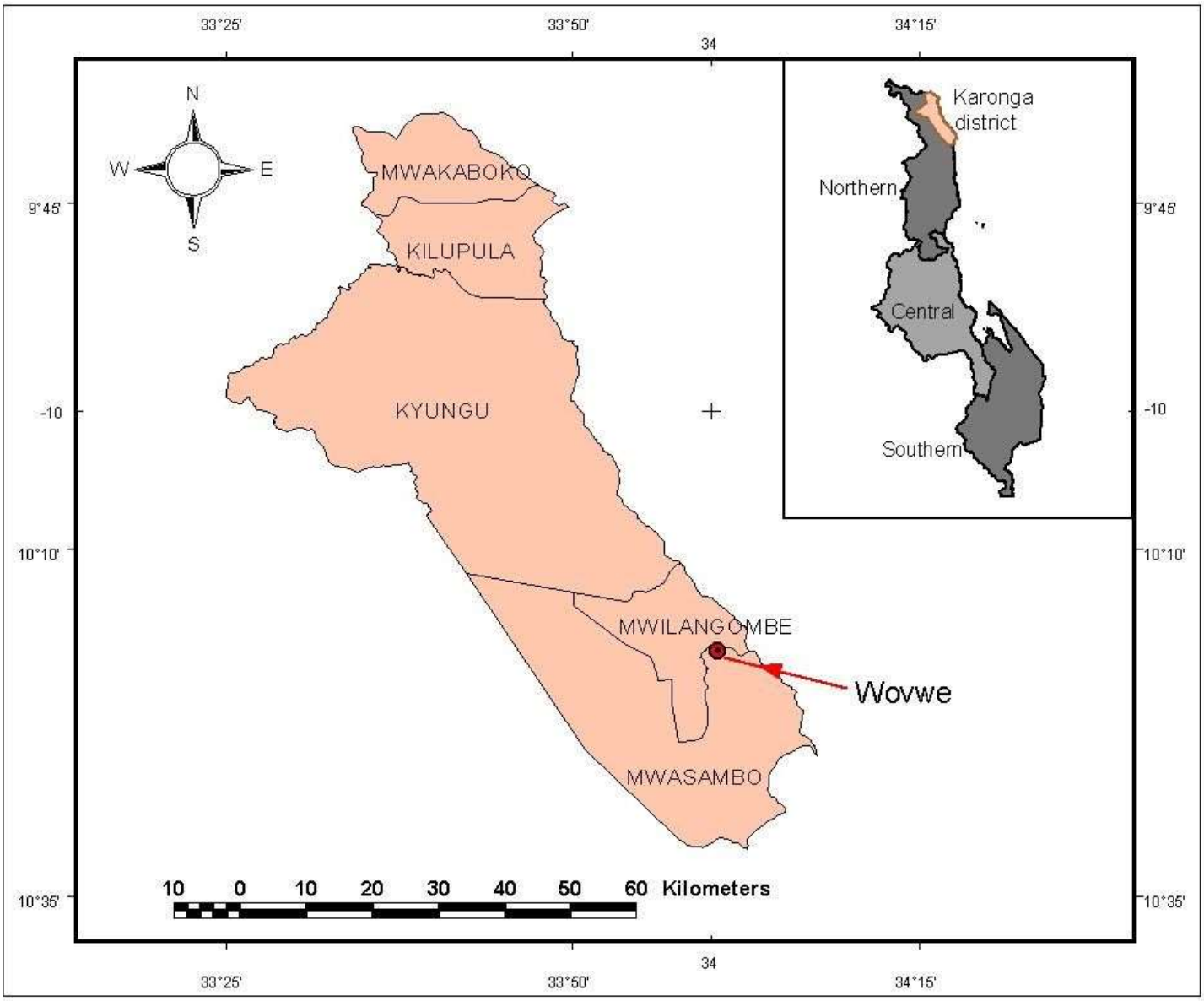

Figure 1. Location of Wovwe Irrigation Scheme.

speaking people, with small number of other language groups represented. Culturally, the population believes in male supremacy in decision making, which bestows women less opportunity to fully participate in all socio-economic endeavours.

Wovwe Rice Irrigation Scheme was developed in 1974 with an initial irrigable area of about 170 ha. This scheme, along with other 15 smallholder irrigation schemes in Malawi were financially supported by British Aid and Chinese Agricultural Technical Mission (CATM), which was funded by Taiwan Assistance Technical Programme (Mphande, 1984). The average farmers' land holding size is 0.25 ha. The main type of soil is sandy clay and the main crop grown is rice with sweet potatoes, vegetables and maize grown in places where water is inadequate particularly between August and October. The main distribution system is a 3.7 km lined canal diverted from Wovwe River, which also supplies water to a 4.5 MW Wovwe mini-Hydro-electric power plant and two other rice schemes at Fuliwa and Mphinga upstream of Wovwe. Wovwe irrigation scheme was later expanded to 365 ha in the 1980s. This are demands water consumption of 40,320 m^3/day of water during dry season although 39,440 m^3/day of water permit was issued (Gondwe, 2008). The Government of Malawi is planning to rehabilitate 3100 ha of existing irrigation schemes, including schemes at Bua (340 ha), Wovwe (365 ha), Hara (230 ha), Manthimba (250 ha) and Dickson (100 ha) (Government of Malawi (GoM), 2012).

Wovwe Water User Association (WWUA) was established in 2002 with a view to transfer of functions and control of Wovwe Irrigation Scheme from Government of Malawi to WWUA, an exercise that was officially completed in 2006. The Association covers 13 villages with 1500 registered members of whom, 1165 are men and 335 are women. The farmers were distributed in 15 blocks each comprising about 20 to 25 ha of irrigated land. The main objectives of WWUA were to increase farmers' income through more productive and sustainable irrigated agriculture and to

reduce the government budget, through farmer participation in operation and maintenance of the irrigation scheme. In the area of maintenance, the government shall be responsible for the maintenance and repairs of weirs, main canal, sand traps and main roads; whereas WWUA shall be responsible for minor works including secondary canals, earthworks to restore protective bands, removal of weeds from all water courses, maintenance of service roads around the schemed-silting and cutting of grass. In addition, the agreement provides the handing over all equipment, plant, machinery and facilities to the Association.

As a legal entity, WWUA was granted water right in 2005 mandating it to abstract a volume of 3,944.6 m^3/day from Wovwe River for irrigation purposes at an annual rental of Malawi Kwacha (MK) 41,025, which is equivalent to US$ 295. This area demands water consumption of 40,320 m^3/day of water during dry season although only 39,440 m^3/day of water permit was issued (Gondwe, 2008). Each member of the Association is allocated a share of the water fee based on the size of his/her farm. Each farmer is required to pay MK 500 (US$ 3.6)/plot/season in addition to a membership fee of MK 250 (US$ 1.8) annually. Water right application was facilitated by the government through its implementing partner, Concern Universal, who was given the authority to process water rights applications. Water management, which includes allocation and distribution, is the core function of the Association in accordance with WUA constitution. Water allocation and distribution is primarily on rotational basis to blocks, which is done by a Water Guard, an appointee of WUA, in consultation with block committees. The Block Committee is responsible for allocation of water to block units on rotational basis. Individual farmers also get water on rotation to their plots through block units committees.

Data collection

Data collection involved desk top studies, questionnaire survey, and observations. It also involved interviewing officials from responsible Ministries at district and national level, traditional leaders, WUA Board members and selected registered farming families. Farming families for questionnaire survey and group discussions were sampled using probabilistic sampling approach, which utilizes some form of random selection. The sample size for the study was determined using Equation 1 (Krejcie and Morgan, 1970):

$$n = \frac{\chi^2 \times p \times (1-p) \times N}{e^2 (N-1) + \chi^2 \times p \times (1-p)} \quad (1)$$

where N is the total population size; n is the sample size; e is the degree of accuracy expressed as a proportion (0.05); χ^2 is the chi-square for 1 degree of freedom at the desired confidence level (χ = 1.96 at confidence level of 95%); p is the population proportion (assumed to be 0.50 since this would provide the maximum sample size.

The sample size for the population of 1500 and a margin of error, e of 5% is 306 farmers. It was intended to administer questionnaires to 21 farmers in each of 15 blocks, but owing to some difficulties in the field the number of administered questionnaires in each block varied from 18 to 21 and a total of 290 questionnaires were administered. In each block, farmers were selected randomly with an assistance of village and WUA leaders taking into consideration the location of their farms within each block across the entire scheme. To be able to identify equality of water distribution in the blocks, seven respondents each were randomly selected from the head, middle and tail of the irrigation canal, respectively. This was in line with the hypothesis that farmers from each of these three sections experience diverse water level satisfaction. Five to six women farmers in each block of 21 respondents were selected in order to follow the proportion of women to men farmers in the WUA of approximately 1:3 in accordance with the statistics of membership of WUA.

Key interviews and focus group discussions (FDG)

Qualitative information was obtained by way of participatory rural appraisal tools such as focus group discussions with farmers. The interviews were arranged and conducted to collect information from Irrigation Water Management Specialists, Divisional Principal Irrigation Officer, District Agricultural Development Officer, District Agricultural Extension Officer, The Wovwe Irrigation Scheme Manager, Water Users Association President, Chiefs and members of WUA standing committees (This list did not necessarily focus on what was done and/or gathered).

Focus group discussions with farmers involved to a total of 90 farmers, 6 farmers in each block. Suitable participants of the FDG in each block were identified and participation was voluntary. The discussion for each group was held separately in variety of locations convenient to farmers of the block in question. A moderator introduced the topic for discussion, which included the aims and agenda of the meeting, and encouraged the group to participate in the discussion openly. The discussions involved wide range of aspects including how they access water at their individual farm, issues of conflicts and how they relate with their neighboring farmers, how they participate in WUA activities and decision making, their willingness to pay for water and membership fee, women representation in standing committees, general satisfaction about WUA operation (resource mobilization, leadership, structure maintenance, water distribution), their involvement in WUA elections and attendance at the meetings. In terms of capacity building questions were asked about the trainings they had been provided, whether the trainings were effective in terms of efficiency of water utilization and crop productivity.

Questionnaires and observations

To get information from WUA members, a structured questionnaire containing both open and closed-ended questions were formulated to permit the respondents to articulate their views and knowledge on different aspects of the project. Households, who were beneficiaries of the schemes, were interviewed in a variety of locations convenient to an individual. Respondents were selected at random within each block across the entire scheme, but gender was taken into consideration. The questions were designed to seek respondents' views of how water is accessed at their individual farm, issues of conflicts and how they relate with their neighboring farmers, participation in O & M and decision making in their in WUA, willingness to pay for water and membership fee. Information was also sought on women involvement in farming and WUA activities, women representation in management standing committees, general satisfaction about WUA operation (resource mobilization, leadership, maintenance of irrigation structures and water distribution), involvement in WUA elections and attendance at the meetings. In terms of capacity building, questions were asked on the effectiveness of the training they have received.

Specific questions were designed for women farmers, which were tailored to gather information relating to challenges women face and whether the challenges were related to their spouses, society or WUA executive. The respondents were free to give their views and perception because each respondent was interviewed alone to avoid interferences from others, despite the fact that the method was strenuous and time consuming. Another set of structured questionnaire was designed and administered to both

former and current WUA presidents to collect general information on Association and specific information on O & M, achievements and constraints of their operations, training provided to them, relationship of WUA with government department and chiefs, water distribution and allocation measures, procedure to resolve water related conflicts, collection of water charges and fund raising and composition of committee in terms of gender.

The questionnaires were designed in English, but were administered in Tumbuka, a widely spoken local language in the study area. The respondents were generally able to responds to the questions, but where necessary respondents were assisted by research assistants who have received instruction and guidelines on how to administer and fill questionnaires. The majority of the respondents were literate.

Direct observations across the entire irrigation scheme were carried out in the field simultaneously with questionnaire survey. Observations focused on the operation and maintenance of the irrigation structures, protection bands service roads and gender involvement in both farming and WUA activities. Observations were made to cross check with the information obtained from the Ministry officials and from beneficiaries.

Data analysis

The qualitative information collected during the discussions with different sources outlined was grouped together according to specific questions and summarized in percentages and tables. Qualitative data was analyzed based on specific concepts that were derived from the set objectives such as conflicts resolutions, legal framework, water access, operation and maintenance and so forth. Microsoft Office Excel 2007 was used to tabulate the variables and for analysis data.

RESULTS

Water allocation and distribution

About 15.6% of the farmers were not satisfied with water allocation, but the remaining 84.4% reported different level of satisfaction from acceptable to very high satisfaction (Table 1). Those who are satisfied indicated that the schedule of water allocation allows farmers to plan for absence of a clear schedule of water allocation potential that may give rise to water related conflicts in the long run. It was also noted that the level of farmers' satisfaction to water access has decreased after the establishment of Water User Association. For example, while 71.1% of farmers rated the services as high to very high before WUA was established; the same level of satisfaction was reported by only 36.7% after WUA was formed. On the other hand, only 8.9% were not satisfied before WUA was established, but post WUA dissatisfaction increased to 15.6%, which is inconsistent with the objectives of establishment of WUA. Some of the reasons brought forward by the respondents included insufficient water in the river due to inadequate rainfall the region was experiencing at the time of the study. Other reasons included illegal water abstractions from Wovwe River into informal rice schemes at Mphinga and Fuliwa, which were commissioned upstream of Wovwe Irrigation Scheme. Water shortage is particularly experienced during dry season from August to October.

Although some farmers were dissatisfied with water availability, the majority (97.6%) of them reported that WUA have established good water distribution plan measures, although this does not necessarily provide equal water distribution to farmers. In accordance with all respondents, equal allocation of irrigation time favors farms that are geographical closer to water distribution canals. About 58.5% of the respondents reported that farms near secondary canal have unfair advantage partly because they have an opportunity to use water more than allocated time and because they are not affected by the hydraulic efficiency of the canals. However, 37.2% of the respondents did not see any difference while 4.3% were non committal. The shortage of water was evident at the tail end of the distribution canal where about 45 ha of rice fields were converted to less water demanding maize crop.

It was also observed that illegal diversion of water is practiced by some farmers against the planned water allocation schedule because of insufficient quantity of water received from Wovwe River, which cannot meet water demand of all farms. WUA may improve availability of water to farmers by increasing hydraulic efficiency of the secondary and tertiary canals and reduce seepage loss and by implementing efficient on-farm irrigation practice. At the time of study, only 22% of the farmers had good supply, 30% considered supply was manageable, but 48% had insufficient water within the past 5 year's period. It is evident that decentralization of irrigation system did not result into greater equity of water supply.

Operation and maintenance

Operation and maintenance (O & M) is fundamental for the sustainable operation of the irrigation scheme as it promotes water use efficiency and hence increased crop yield. All respondents confirmed that they are involved in operation and maintenance of irrigation scheme, but provision of manual labor was the most common form of participation. About 87.2% of the respondents participated through manual labor, which is often limited to minor works such as slashing and removal of weeds in canals, earthworks and de-silting sand especially at the head works. With regards to WUA's effectiveness on operation and maintenance, about 45.5% considered it to be average, 34.1% said it was good while 18.2% rated it as poor (Table 2).

Some of the weaknesses reported by respondents include inability to enforce by laws to ensure clean canals and failure to repair some service roads, which limit accessibility during harvesting. It was further observed that the presence of aquatic weeds in the tertiary canal affected water distribution, which limited water supply into

Table 1. Farmers' satisfaction on access to water (%).

Water availability	Very high satisfaction	High satisfaction	Moderate satisfaction	Acceptable	No satisfaction
Pre WUA	23.3	47.8	13.3	5.6	8.9
Post-WUA	8.9	27.8	41.1	5.6	15.5

Table 2. Association's effectiveness in O & M.

Quality	Good	Average	Poor	Not sure
%	34.1	45.5	18.2	2.2

the fields at the tail end of the canal. In view of O & M training, about 91.7% of respondents did not receive any training because training was offered to the members of Irrigation Committee responsible for O & M of canals.

It was observed that women were involved in all maintenance activities such as canal cleaning and carrying material for canal maintenance, just like men except de-silting sand at the head works. The participation of women is encouraging as many scholars have emphasized the need to integrate women not only into farm activities, but also into agricultural investment programs including right to land as it relates to the irrigation development (Belsare, 2001; Poutiainen and Mills, 2014).

Operation and maintenance plan is important to ensure the sustainability of the irrigation schemes as it affirms the required stages with specific responsibilities and technical and financial obligations of both parties involved. WUA had no O & M plan, but operation and maintenance of the scheme was scheduled twice every year between cropping seasons. Unfortunately, stakeholders were not involved, which means financial compulsion and responsibilities for the sustenance of the scheme was not known to them.

Conflict resolution and management

With regard to WWUA, respondents identified four areas of conflicts, namely; illegally blocking entry of water to other farmers' fields against water allocation schedule (83.2%), secretly opening water through a band from a neighbor's farm (11.4%), livestock entering into somebody's plot (4.7%) and witchcraft accusations (0.7%). All conflict cases are handled by WUA through its standing committee known as Jury, but minor cases are resolved either by the Block Committee or amicably between conflicting parties themselves. Those involving witchcraft, depending on their severity, were sometimes referred to the Chiefs. In accordance with the 56.8% of respondents, there were fewer conflicts before than after establishment of WWUA. The potential reasons are that farmers are now taking farming as business, which has increased cultivated land area, consequently increasing water demand. It was also noted that water supply from the Wovwe River has decreased because of draught and increased abstraction by upstream water users. However, some farmers have expressed dissatisfaction with WWUA`s conflicts resolution body because decisions on conflicts resolution are based on favoritism (21.9%), which are influenced by social relations and corruption practices.

Relationship with government departments

In accordance with the respondents, only the Department Of Agriculture through Extension Officers supports the farmers well in matters of agronomy, but the Departments of Irrigation and Public Works were rated poorly. In accordance with the transfer agreement signed between the government and Wovwe Water User Association, the government is responsible for the maintenance and repairs of major works which include main canals, weirs, head works, main roads, sand traps and overpasses. Former WUA president recalled some rehabilitation works was done once on tertiary and secondary roads two years earlier, when the Head of State visited the scheme. Otherwise, governments departments have seldom fulfilled their responsibilities, which suggest that decentralization of Wovwe Irrigation Scheme was done to shift the recurring cost of irrigation from the government to the farmers. It is important to recognize that straightforward decentralization of irrigation schemes may not effectively work in smallholder developing countries, majority (75%) of who own less than 0.5 ha farms. Vermillion (2005) and Giordano *et al.* (2006) observed that even when all preconditions for a successful irrigation management transfer (IMT) are met; it is unlikely that IMT will work for smallholder farmers if government shifts all recurring costs of irrigation to the poor farmers.

Role of traditional leaders

Since the irrigation schemes are operating within the

administrative areas of Chiefs', it was felt important to establish how WUA relates with the traditional leaders. In general, both traditional leaders and the Association members reported the existence of good relationship between them. This is substantiated by the support the Chiefs extend to WUA in mobilizing farmers on their behalf for WUA activities, playing an advisory role, presiding over WUA election together with government officials (District Agricultural Development Officer, District Commissioner etc) and assisting in resolving disputes beyond the WUA structure such as disputes between the WUA and a farmer who is not a WUA member. However, some chiefs feel that their control has been taken over as WUA constitution does not allow them to be part of the executive or any other WUA committee. One chief recommended their inclusion in Jury rather than being involved to resolve complex cases only, which suggests that potential conflicts may arise in the future between the chiefs and WUA executives. The fear on the part of traditional leaders in losing their control and decision on land and other related issues have also been observed in Zambia (Poutiainen and Mills, 2014).

Financial resource mobilization and management

Financial resource is necessary, but not sufficient factor for the sustainability of Water User Association. The major financial resources mobilization is largely through WUA membership entry fee of MK 250 (US$1.8), which is renewed annually and a seasonal water subscription fee of MK 5,000 (US$ 36) per ha of land owned by the farmer members. In addition, the Association may also raise funds from fines, loans from the bank, grants and donations. The Association fines are levied from non payments of water fee, non attendance of association meetings, damage to irrigation structures, illegal use of water, non participation in maintenance work and from livestock, which are damaging fields in the scheme.

However, only 22.7% of the respondents rated the financial management of WUA as good, but 40.1% rated performance as average and 32.2% as poor. It was observed that only 53.2% of the respondents were willing to contribute water user and membership fees largely because the collected funds are feared to be diverted for unintended purposes. Even those who are willing to pay do so because of fear of their land being confiscated by the local government. It was noted that fees were collected without issuing receipts and even the amount collected was misappropriated. For example, audit report revealed misappropriation of about MK 1 million (US$ 7,205) leading to the change of WUA executive. Financial accounts indicated that annual water and membership fee were not collected in 2004, 2006 and 2007. However, all farmers interviewed reported that they were contributing both water user and membership fees annually. It is estimated that at least MK 1,537,500 (US$ 11,077) was collected annually and misappropriated by the Association executives.

The capacity of an Association to effectively carry out its operation and maintenance of the irrigation scheme depends largely on its stable financial status, which according to Nelson (2002) is determined by WUA`s water fee collection performance. Fee collection performance (FCP) is defined as the ratio of the annual amount of water charges collected to the annual amount of water assessed (FCP = FC/FA). With regard to Wovwe Water User Association, FCP increased from 39% in 2003 to 48% in 2004 (International Fund for Agricultural Development (IFAD) Supervision Report, 2004). Additionally, FCP calculated in 2005 was about 67%, which is relatively above the minimum requirement of 60%, but dropped to 0% in 2007 as water charges were not collected.

The survey observed that 59.1% of the members of the Association lack confidence in their executive committee and want the government to take the responsibly of O & M of the scheme because of poor financial management of WUA executives. Some farmers proposed that the government should manage funds on their behalf because their leaders are not trustworthy, which is contrary to the participatory irrigation management principle. The performance of the scheme was considered to be moderate to high by 84.1% of the respondents before WUA was established, but the same has decreased to only 63.6%. In fact, 59.1% of farmers had high satisfaction of the system before it transferred to WUA, but only 25% share the same opinion after WUA was established, which indicates that WUA`s performance is declining. It is thought that financial management aspect had attracted disapproving comments from the beneficiaries of the scheme. To build their capacity by way of sharing experiences, members of the Association have opened up links with other WUA both internally and outside Malawi and have had some exchange visits to Zomba, Hara and Chonanga all in Malawi as well as Italy and Tanzania.

Crop productivity

With regard to crop productivity, the farmers were asked to compare the level of yield pre and post formation of WUA. It was observed that about 59% perceived that crop yield have decreased after WUA was formed against 25% who perceived that the crop yields have increased. About 5% of the respondents were non-committal and 11% did not perceive any change in crop yield. However, the major problem appears to be inadequacy of farming inputs such as fertilizers, which is considered expensive, compared to the value of the crop yield they get from the market. It was noted that previously farmers sold their crops to Agricultural Development and Marketing Corporation immediately after harvesting, but excess

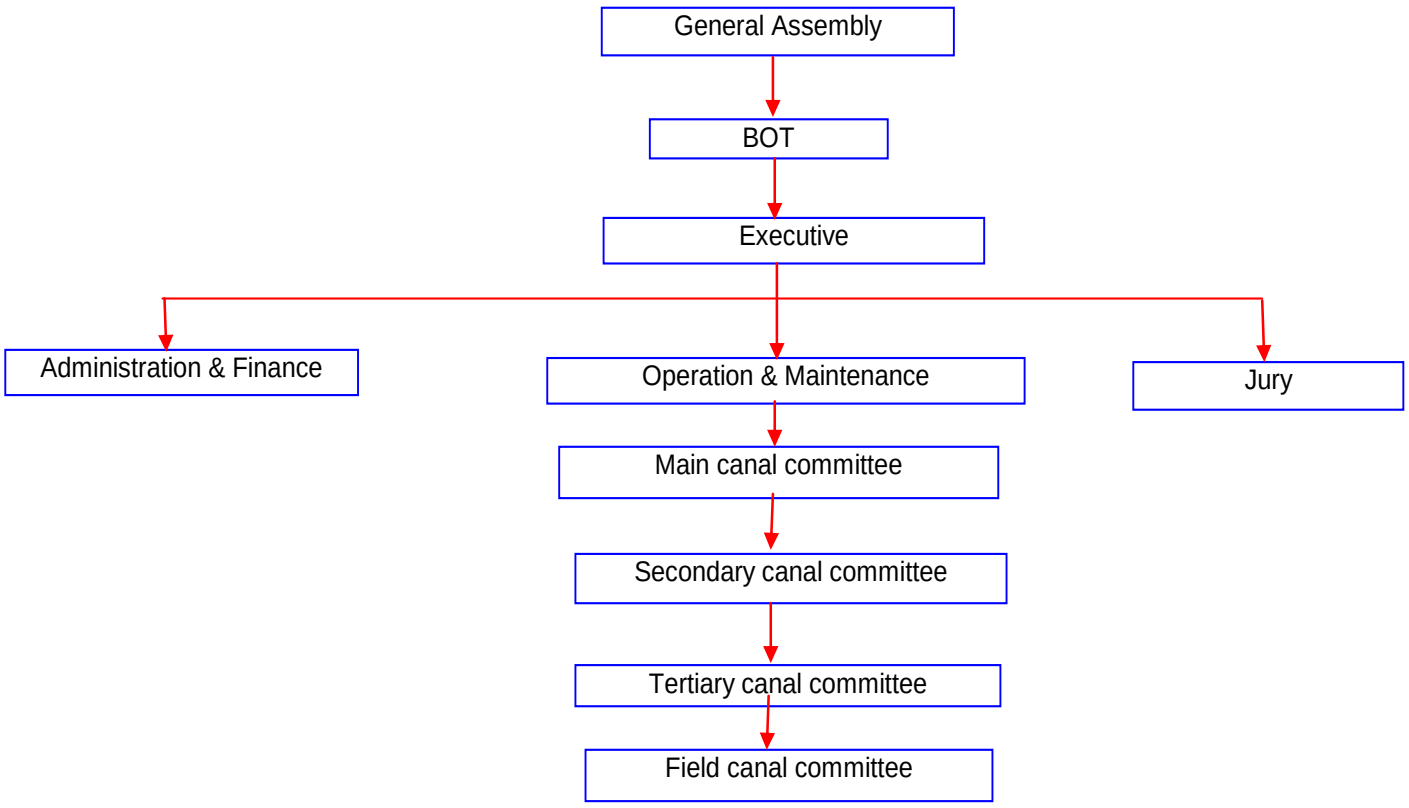

Figure 2. Organizational structure of WUA.

produce is now sold to individual buyers at a cheaper price. Elsewhere, case studies of participatory irrigation management around the world has shown that farmers' participation in water management had led to efficient water use, which increased water supply to tail end users, resulting into improved net farmers' income, increased crop intensity and yield (Vermillion, 1997; Ghosh and Kumar, 2012; Sam-Amoah and Gowing, 2001; NIACONSULT, 1993).

Constitution, organization and management of the Association

WUA structure is the basic organizational relationship of committees that form part of the Association with specific roles and responsibilities with different reporting lines (Figure 2). The General Assembly at the summit is responsible for electing the Executive Committee and any other committee, taking on all policy decision, adopting or amending the articles of by-laws of the Association, acting and exercising final authority in all matters affecting the Association and hearing and passing on the reports.

It is worth mentioning that 86.6% of the respondents know some of the existing by-laws, but 13.3% did not know any by-law. In general, 77.3% of the respondents were satisfied with the existing by-laws, but 13.6% were not satisfied and 9.1% were non-committal. Therefore, it can be concluded that by-laws are not effectively followed by WUA, but farmers practice what they prefer and not what constitution demands. This may threaten the sustenance of the Association and irrigation scheme in the long run unless farmers and WUA executives are educated on the importance of abiding with by-laws.

The selection of The Executive Committee of the Water User Association is critical to successful implementation of IMT. Constitutionally, it is required that the President, Vice-President, Secretary, Vice Secretary, Treasurer and 13 other members of the WUA be elected by all members through a secret ballot at the annual general meeting and that the members so elected should hold office for three years until the next election of a new committee. All members of WUA are eligible to vote. With regard to farmers' participation in the election, the study considered the previous and current executive committees. About 63.3% of the respondents voted for the previous executive, but only 34.5% of the respondents voted the current Executive Committee. These statistics show that farmers' zeal of participating in election is dwindling.

It was observed that education, good behavior, trustworthiness and good interpersonal relationship were

the main qualities which members look at when they elect members of the Executive Committee. For the President, wisdom, being calm and courageous, having leadership skills, and having another responsibility in the society are some of key qualities. A Treasurer is also expected to have knowledge of record keeping, enough personal resources, fear of being jailed and corruption free reputation are some of the key advantages. In general, education is a key factor (61.4%) for being elected to WUA executive. However, only 19.5% of the farmers have education beyond primary school level. In accordance with EMIS (2009) report, the drop-out rates for girls in primary schools sharply increased in Standard (Grade) 7 and 8, reaching rates nearly six times higher than that of boys. This sharp drop-out rates in higher primary schools in Malawi may be gender related (Mwamsamali and Mayo, 2014). As a result, primary school completion rate in Malawi is higher for boys (53%) than girls (45%), which means women are less educated and are therefore more disadvantaged to compete for similar positions with men.

It is noteworthy that 52.3% of the respondents would vote for anyone with required qualities regardless of the gender, but 31.8% would only vote for a man and 15.9% would only vote for a woman. Surprisingly, out of the 15.9% of those who said they would vote for a woman, only 14.3% of them were women, suggesting that women are not confident in themselves. These results suggest that there are not enough gender sensitization programs regarding women involvement in decision making positions. Building gender responsive WUA needs to be encouraged as it promotes women voice in water governance. There is a general agreement that women play a central role in provision, management and safeguarding water. On the post of Treasurer, about 61.4% of the respondents preferred a woman, but only 4.5% preferred a male treasurer. This implies that women are more trusted than men in financial management. Those that said they would vote for a woman highlighted several grounds including being able to keep money, rarely use of alcohol, trustworthy, less corrupt and they are afraid of being imprisoned.

It was appalling to learn that about 63.6% of the respondents have never attended to any WUA meeting over the last year. In fact, only 4% have attending more than one WUA meeting, while 27.8% have attended only one WUA meeting, which suggests that only a few farmers are committed and actively involved in decision making process. The information on calls of meetings is done through chiefs, posters and letters through block committees who inform their members in person in the fields. The majority of the farmers (87.3%) preferred getting the messages through chiefs who use their messengers to publicly announce in the village early in the evening when everybody is expected to be at home.

Smallholder Flood Plains Development Programme (SFPDP), under which WWUA was formed, advocates participatory approaches that promote farmers participation in the overall management of the irrigation system upon equipping them with skills through various trainings to be organized. However, the Association is constrained with poor attendance of farmers during training sessions, which implies that only a few farmers are reached out and consequently affect the implementation of on-farm water management techniques as well as the overall participation in operation and maintenance work. Of the 90 farmers involved in focus group discussion on water management techniques being applied on farm, only 25 (27.3%) were at least able to mention some. Only one farmer confidently stated the water requirements at varying crop stages. Poor attendance was revealed when asked to give turnout details at the meetings for both male and female members (Table 3).

The performance of local institutions (WUA) can best be evaluated by the extent to which their capacity is built and how they competently undertake all the essential tasks involved in irrigation management thereby smoothly implementing IMT. It was observed that 59% of farmers received training in crop management, but only 13% were trained in water management. Both groups perceived that the training was effective and satisfactory although they were learning so many modules within a short time, which gave them difficulties to implement what they had learnt in WUA activities. It should be understood that successful capacity building requires prolonged and patient process of learning taking into consideration the farmers understanding especially when majority have low literacy level.

Gender mainstreaming in the Association

Water User Association offers an opportunity for mainstreaming women's participation and gender equity in irrigation and water management thereby reducing the risks of gender biases as well as improving the performance at all level. For instance, Peter (2004) observed that involvement of women can make activities more effective, inclusive and equitable as women undertake most agricultural occupations as men, in addition to other livelihood activities. The findings of this study indicate that in all families, women are involved in farming activities just like men including harvesting, transplanting, weeding and canal clearing, although they are seldom involved in decision making process. It was observed that 83.3% of women interviewees reported that they are not allowed by their husbands to sell the produce alone because their husbands fear that they will mismanage accrued funds. On the contrary, men mismanage funds themselves through drinking alcohol. The majority of women who sell the produce without interference of men, do so if the crop was harvested from their personal plots.

Table 3. Turnout of members at AGM and maintenance work.

S/N	Sex	Annual General Meeting	Maintenance work
1.	Men	200-250	600-700
2.	Women	60-70	150-200

The SADC Declaration on Gender and Development (1997) in which Malawi government is a signatory, advocates for a 30% share of women representation in decision making positions. With this in mind, it was deemed essentially creditable to also ascertain gender representation in Water User Association's standing committees particularly in key positions of president, secretary and treasurer in both new and old executive. In an old WUA executive, women constituted 20% of the members, but women are not represented in the new WUA executive, which require devising mechanisms of deliberately incorporating women in the executive committees. WUA Executive Committee being on the driving seat of all operations including making decision as well as implementing government policies, women inclusion should be a must. Low or lack of women participation in this committee could also be understood from the social and cultural perspectives particularly in societies where male dominance is highly respected. On the other hand, all six standing committees have male presidents and secretaries, but 50% of the treasurers are women.

DISCUSSION

An independent WUA needs to have a legal identity that empowers it to undertake its mandate in order to serve its members. Legislations provide legal support and backing to take over control and functions previously assigned to government agency. Malawi government developed various legislations in water resources management that includes National irrigation policy and development strategy (2000), National Water Policy (2005), Water resources Act, Lands Act and Tenure, Water right, handover agreement and Environmental Act.

The National Irrigation Policy and Development Strategy (2000) emphasizes on the development of irrigation schemes with full participation of the farmer beneficiaries from the identification through planning, design to implementation, operation and maintenance. Broad development strategies were developed to realize the policy statement, which includes assisting smallholder farmers to develop and manage new and existing irrigation schemes through establishment of legally constituted local farmer organizations that can assume full ownership of existing irrigation schemes and oversee all matters related to operation and maintenance of these schemes. Secondly, transferring ownership of existing government schemes to the beneficiaries, through participatory methods and sensitizing rural communities through public awareness campaigns, gender roles training programs to encourage them to incorporate female members in their local organizations management committees, ensure that women have equal access to ownership of land.

The sense of ownership of the project is developing among farmers following the establishment of Wovwe Water User Association. The Association has increased farmers empowerment in terms of decision making as major benefits. However, the Association's operations are limited by lack of technical and managerial skills, shortages of water in winter cropping, limited financial resources, low attendance of farmers at WUA meetings and financial imprudence by WUA executive.

The Association constitution defines the main responsibilities and obligations of each tier of the Association within the scope of the Trustees Incorporation Act under which it is registered. The existing operation laws include payment of membership and water fee by all members, membership requirements, rights and obligations of members, termination and suspension of membership, functions and powers of the Association and its standing committees and general provisions, such as disputes settlement. It was observed that the existing laws are not effectively followed by WUA members although 86.6% of the members have admitted that they are aware of their existence. For example, a provision under section 10(6) states that "*Any individual found misappropriating funds of the Association will be requested to pay back immediately and shall automatically lose the office he/she was holding"*. Unfortunately, Association funds were misappropriated by the Association's executives. This led to dissolution of the whole executive, but funds were not repaid to the Association. It was further noted that some members of the Association still wanted to vote back into the office the Association president who mismanaged Association funds against the constitution. Fortunately, the government officials who were presiding over the election refused to allow the constitution to be breached, which resulted in some members boycotting the elections.

The success of WUA depends to a large extent on their ability to raise funds for operation and maintenance and other activities such as provision of training to its members. Misappropriation of funds reduces WUA's ability to fund maintenance of the facilities and promote potential conflicts between the executive and farmers

over contributions. Additionally, further training is required on financial and records keeping. It is worth mentioning that the levels of consumers' satisfaction have a major influence on consumers' willingness to pay for water services (Bhandari and Grant, 2007). Mayo and Nkiwane (2013) reported that Uroki-Bomang'ombe and Lawate-Fuka water supply trusts in Tanzania were able to collect more than double of the funds required for operation and maintenance because the systems were efficiently managed to the satisfaction of water users. Similarly, Behçet and Akin (2014), in their work on Bursa-Karacabey irrigation scheme in western Turkey observed that the effectiveness of fee collection averaged 103%. This means that Wovwe Water Users Association needs to restructure their financial management system in order to improve user satisfaction and willingness to pay for water services.

It is evident from poor attendance of the meetings (20-30%), training and voting that either the majority of farmers are not well informed on the importance of WUA or they have developed negative attitude towards it. In principle, participatory irrigation management (PIM) is an approach for management of irrigation system in which members of WUA share views and management responsibilities for sustainable development of the system (Francis, 1993; Anwar et al., 2008). It is well documented that PIM is all about farmers, and their attitude towards participatory approach is crucial factor that influences their action and behavior while implementing this approach (Mohan and Reddy, 2012; Khalkheili and Zamani, 2009).

Owing to inadequate supply of water from the source, the distribution of water to the blocks and later to the individual farms is intermittent. Therefore, water distribution and delivery is done on rotational basis and is supply driven. However, it was observed that water was used inefficiently both on farm and in conveyance system. As a result, only about 41.1% of farmers showed moderate satisfaction as regards to water access. In a study in Mexico, Wilder and Lankao (2006) observed that irrigation management transfer did not result in greater equity, efficiency or sustainability of water use, although it promoted more farmers' participation. This is contrary to observations made in Philippines where it was reported that participatory approaches has led to more equitable water distribution (Araral, 2009).

Efficiency of on-farm water management may be improved by providing training to farmers in order to boost farmers' motivation, increase water management and crop productivity. For example, in Egypt the training of water users was changed from low priority activity to one which is part of the process of management (Abu-Zeid and El Assiouti, 1997). They further reported that an extensive training program for farmers in WUAs and Irrigation Advisory Services staff was carried out in order to build capacity of WUAs, which was seen as a precondition for sustainability of Participatory Irrigation Management (PIM). Several scholars have observed that manpower planning and systematic training programs are some of the root causes of problems of participatory irrigation management (Adeniji, 2001; Dossah et al., 2003). Adewumi (1990) reported that for sustainable participatory approach to irrigation management, training should be seen as a continuous process. This is because knowledge is dynamic and new techniques and systems are continuously emerging (Saravanan, 2010). It is therefore very important that farmers and WUA executives are trained and re-trained for sustainable development and effective management of irrigation schemes (Dossah et al., 2003).

Men and women participate fairly in farming and WUA's maintenance activities regardless of gender in form of contributing labour. However, women are not involved in key decision making positions because they are not represented in the current executive committee and only 8.3% of the standing committees members are women. Low women representation in water committees were also reported elsewhere (Tadesse et al., 2013; Mwamsamali and Mayo, 2014, Kwangware et al., 2014). In Mbire district, Zimbabwe, Kwangware et al. (2014) reported that women representation in Water Committee is only 25.8%, which was perceived by majority of the respondents (76.3%) as adequate. In majority of cases, social, economic and cultural reasons limited the women participation in the committees. Positive response with respect to gender balance in WUA was reported in Uswaa village in Tanzania where a women chairperson leads a village WUA consisting of 40% of women members (Mayo and Nkiwane, 2013). In Wovwe, women are also denied right to ownership of land and crop produce, which is clear violation of human rights. In neighbouring Zambia, Poutiainen and Mills (2014) recommended to integrate women's land rights, including enforcement of statutory legal target of 30% of land allocation to women and inheritance in the irrigation policy development. They further recommended development of by-laws that will guarantee land ownership/access rights to women, something which Malawi should also adopt.

Similarly, the study has noted some socio-economic implications determining the election of members into these key positions. It was noted that the socio-economic status of an individual to some extent determines the opportunity for an individual to be elected into WUA committees with good education preferential in all the three key decision making position. For example, the new WUA president is a retired scheme manager while the former is a pastor. Similar findings have been observed in other researches both in Malawi and elsewhere. For instance, Kadewere (2005), in his study done at Chingale and Mwamsamali (2007), in his study at Mzimba in Malawi found out that socio-economic status of an individual had an implication on the position one gets in a committee. Mwamsamali and Mayo (2014) in their work

at Mzimba, Malawi reported that those who are elected to the decision-making positions in water point committees were perceived to have high economic and social status within the community. Similarly, Cleaver (1998) found out that a similar criterion was used to get people elected into position of responsibilities in rural areas of Zimbabwe.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Technology tracking: Understanding decisions to adopt, not to adopt, and dis-adopt household greywater filtration systems

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Jordan is one of the world's water-poorest countries. The demand for potable and productive water is ever increasing due to population growth, climate change, increasing numbers of refugees hosted by the country, as well as heightened demand from a growing economy and its different sectors. Household greywater filtration systems (HGWFS) are ideal for repurposing greywater, from wastewater into productive use for small-scale agricultural production. Given that 50 to 80% of residential wastewater is in the form of greywater, there is significant potential for saving fresh potable water and improving household livelihood systems through effective utilization of treated greywater for productive purposes. However, broad uptake of the technology is not forthcoming. This comparative study examines two technology dissemination pathways and their role in influencing household decisions to adopt, not to adopt, and dis-adopt the HGWFSs. Quasi-experimental (cross-sectional) design was utilized with a one-shot survey of 252 households (adopters and non-adopters) selected through a combination of purposive and stratified sampling approaches. Qualitative data was also collected through key informant interviews and focus group discussions separately held with male and female members of the community. It was found that lack of technology tracking was a determinant factor in fostering negative perceptions on the technology up-take and its eventual dis-adoption in two of the governorates considered.

Key words: Technology tracking, greywater filtration systems, dissemination pathways, water saving, gender.

INTRODUCTION

The Hashemite Kingdom of Jordan ranks as the world's second water-poorest country, with annual precipitation of less than 200 mm (Government of Jordan (GoJ), 2009; FAO AQUASTAT, 2014; WHO, 2014). Jordan has a negative water balance estimated at 20% meaning that the country's total water use far exceeds its renewable

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water supply; with the difference covered through pumping from nonrenewable and fossil aquifers, as well as the reuse of treated wastewater (Iskandarani, 2002; Humpal et al., 2012). The demand for fresh water, however, is ever increasing due to population growth, climate change, increasing number of refugees hosted by the country, as well as heightened demand from different sectors within a growing economy. Recent climate change models predict that the region will continue to experience hotter and drier summers which will further diminish their already limited water resources (Intergovernmental Panel on Climate Change [IPCC], 2014; Haddad et al., 2017). Agriculture uses more than 50% of the country's water resources, a disproportionate figure that is not representative of the sector's 3% contribution to the Gross Domestic Product (WANA, 2017). Demand for alternative safe water sources is thus very high and growing.

Greywater is household generated wastewater from the kitchen sink, laundry, hand-wash basins, showers or baths that can be used for toilet flushing or irrigation after treatment (Bino and Al-Beiruti, 2007; Gross et al., 2015). For instance, rural households in Northeastern Jordan generate 12 to 19 L of greywater per capita per day of which 50% comes from kitchens and the remaining from ablution and hand-washing points (Suleiman et al., 2010). On average, a Jordanian household can recover 57% of household greywater for reuse, which can provide daily supplemental irrigation for approximately 20 olive trees grown in a home garden (Al-Beiruti, 2003). The financial benefits of using greywater on rural income are also well documented in the literature. Studies show an increase in income of 10 to 40% resulting from growth in profit due to increased agricultural production and savings from reduced water bills and periodic cesspit cleanings (Al-Beiruti, 2003; Imhof and Muhlemann, 2005; Morel and Diener, 2006). Other benefits recorded in the literature include environmental returns through conservation of freshwater for future use, as well as reduced pollution to underground recharge if treated greywater is used (Jeppesen, 1996; Friedler, 2008; Mourad et al., 2011). In a water-scarce arid environment like Jordan, on-site greywater treatment can help households reduce their demand on freshwater supply, promote water conservation, and provide a critical input for home gardening (Boufaroua et al., 2013; Gross et al., 2015). Several variations of HGWFS are widely disseminated throughout Jordan as part of the country's strategy to reduce demand on fresh water.

Literature on technology up-take indicates that adoption or the decision to start using a technology is not an end by itself and that there is a lot to learn from technology "tracking" after its adoption (Rogers, 2003; German et al., 2006). Technology tracking is a way of following up on the fate technologies after their adoption. Technology tracking acknowledges the challenges in blanket recommendations of technologies and innovative packages and seeks to highlight the effects of variations at the household level, including differences in capabilities and endowments, household labor, gender roles, etc., and their effect on the continued adoption and diffusion of technologies (Chambers et al., 1987; Scoones and Thompson, 1994). Through technology tracking, we get better insight into major constraints hindering their further dissemination; biophysical, social or economic implications of adoption; and opportunities to adapt the technology to respond to unforeseen challenges (Reij and Waters-Bayer, 2001; de Grassi and Rosset, 2003). This is especially important in the case of the household greywater filtration systems (HGWFS), as long-term application of untreated or inadequately treated greywater could have significant environmental, social, health, and economic implications.

Two HGWFSs were considered in this study, the first developed and promoted by the National Center for Agricultural Research and Extension (NCARE) and the second promoted by an international non-governmental organization, Mercy Corps (MC). The two units costed the same, were about the same size, served the same purpose, and were disseminated in four governorates of Jordan. The main difference between the two HGWFSs lied in the type of filtering medium used to treat the greywater. One used volcanic tufts while the other used sand. Each HGWFS installed in targeted households were equipped with a drip irrigation system to minimize physical contact with the treated greywater, to reduce the magnitude of the odor, and increase the water use efficiency. For the purposes of this study, the two HGWFSs were considered as one and the same. Moreover, in this study *adoption* is defined as a household's decision to start using a new technology; *non-adoption* as a household's decision not to use a new technology for various reasons, including lack of full knowledge about the technology, lack of financial resources, lack of access to essential inputs, etc., and dis-adoption is conceptualized as abandonment of the technology after trying the technology for some time. Dissemination pathways are also key factors in this study and are conceptualized as the mechanism through which information on the technology is communicated with different stakeholders. Different dissemination pathways with different information packages and modalities of communication will thus have different effect on technology adoption (Mauceri et al., 2005). The viability of the dissemination pathway or the method by which knowledge is transferred, as well as technology tracking after adoption, that is, the advisory and monitoring services provided during the adoption and post-adoption phases, thus make a difference in influencing households decision to sustainably adopt a technology (Rogers, 2003; German et al., 2006; Nyasimi et al., 2017). This paper assessed the effect of the different dissemination pathways and technology tracking systems on households' decision to adopt, not-adopt, or dis-adopt

HGWFS. Specifically, the study considered the effectiveness of dissemination pathways in (i) identifying potential adopters, (ii) transferring information, and (iii) facilitating access to the technology; and examined the technology tracking mechanisms in place to ensure continued adoption. The resulting benefits of the technology were analyzed using a gendered lens to shed light on the differential gains or losses for men and women under the different scenarios.

MATERIALS AND METHODS

Description of water supply conditions in the study area

The study covers four villages in Mafraq, Madaba, Karak, and Ma'an governorates which in a sequential progression represent the north, central and southern parts of Jordan. The villages are characterized as rural and peri-urban settlements connected to municipal fresh water supply systems, but using on-site sanitation systems (cesspits or cesspools). Municipal water in the sample governorates is supplied for few hours with low pressure once a week, which is stored by households in water tanks on their roofs or underground. Most households live under the condition of continuous water shortage and often purchase additional water from private vendors to meet their household and agriculture needs. They also adjust their water use practices (using less water or doing laundry and cleaning once a week) in an effort to reduce water stress conditions, and ensure water is available for household uses until the next water supply day.

Research design

Data collection

Quantitative and qualitative data were collected from the four villages using a combination of methods including household surveys, focus group discussions (FGD), and key informant interviews (KII). All data collection efforts were gendered so as to effectively capture the differential gains or costs to men and women in the community associated with access to and management and use of the technology. Quantitative data was collected using a cross-section quasi-experimental design which involved a one-shot survey of 252 households selected using a multi-stage sampling approach. First, the governorates and villages were purposively selected to ensure the inclusion of the villages in Ma'an, Mafraq, Madaba and Karak where MC and NCARE introduced the grey water filtering technology. At the village-level, households were stratified into adopters and non-adopters and random samples drawn from each stratum. Using Power Analysis, the minimum sample size needed to ensure XX% confidence and YY% standard deviation (SD) precision was determined to be 252 households. The sample households were then distributed across villages proportional to the population sizes and proportional to the number of adopters and non-adopters within each village. Accordingly, a total of 115 adopters and 137 non-adopters were included into the study and were distributed as presented in Table 1. Given that the population of adopters was small, the research team made a decision to include into the sample all adopters of the technologies in the four villages and randomly selected non-adopters to serve as the control group. 15% of the respondents in Ma'an and Mafraq were women, while women represented a higher percentage (51%) in Madaba and Karak. This was because more women were targeted by NCARE in Madaba and Karak.

Additional information on men and women's perceptions and experiences with regard to the grey water treatment technology was solicited through 16 FGDs, including 4 with men and 4 with women groups from among adopters of the HGWFS: one set (male and female) for each governorate and 4 with men and 4 with women groups from among non-adopters. The FGDs focused on perceptions of adopters and non-adopters around water shortage, roles and responsibilities of family members in household water management (fresh and greywater), any differential access to information and training, willingness to pay for the HGWFS installation, and considerations taken in household decision-making processes. In addition, a total of 12 interviews were held with key informants, including relevant individuals at the International Center for Agricultural Research in the Dry Areas (ICARDA), NCARE, International Fund for Agricultural Development (IFAD), Mercy Corps, and heads of community-based organizations (CBOs) in charge of disseminating the technology.

Empirical model

Following Swagata et al. (2008), the binary logistic regression model was used to analyze households' adoption decisions of HGWFS. The dependent variable *Decision to Adopt* the HGWFS is a binary variable with a value of 0 and 1 representing the decision to reject or adopt the technology, respectively. The explanatory variables covered a set of socio-economic conditions selected based on the key informant interviews held with relevant individuals. These include income, garden size, number of fruiting trees owned, average age of olive trees, connection to municipal sewage systems, the household size, and location of the governorate. The binary logistic regression used to analyze the relationship between the dichotomous choice variable (*Y*) and both categorical and metric explanatory variables can be formulated as follows:

$$Y = \begin{cases} 0 & if\ a\ household\ is\ not\ willing\ to\ adopt) \\ 1 & if\ a\ household\ is\ willing\ to\ adopt \end{cases}$$

I was hypothesized that a household will be more likely to adopt the HGWFS if the logit (*Z*), derived from the willing respondents, is greater than the one derived from those unwilling to do so. *Zi* of the i^{th} household is a linear function of *n* explanatory variables *X*=(*X1,…,Xn*):

$$Z_i = ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum_{k=1}^{n} \beta_k x_{ik}$$

where xi is the observed value of the explanatory variables for observation *i* and

Pi = Probability (Yi=1|Xi=xi)

where *β0* is the intercept term and *βk* are the coefficients associated with each explanatory variables *Xk*. These were estimated using Maximum Likelihood Estimation (MLE) method. The Statistical Package for the Social Sciences (SPSS) (IBM Corp., 2011) was used for all analysis in this paper.

RESULTS AND DISCUSSION

Research shows that decisions to adopt a technology are influenced by several factors, such as its compatibility, the relative advantage it offers, complexity of the

Table 1. Household survey.

Governorate	Madaba	Karak	Ma'an	Mafraq	Total
	NCARE		MC		
Adopters	8	5	74	28	115
Non-adopters	8	9	41	79	137
Total	16	14	115	107	252

Table 2. Description of the variables used in the analysis (Own Elaboration from Survey, 2017).

Variable	Description of the variable and their specific codes
ADOP	Adoption of the HGWFS
Socio-economic characteristics	
Principleincome	1=government, 2=military, 3=pension, 4= self-employment, and 5=labor income
Gardensize	Size of the household garden (in dunum)
Olivefruiting	Number of fruiting olive trees
Oliveavgage	Average age of olive trees
Municipalsewer	Household connection to municipal sewage system (0 = not connected; 1=connected)
Hhsize	Size of the household
Governorate	Name of governorate (0=Mafraq, 1=Ma'an)

technology, its triability or ability to be tried out in part, its observability or the degree to which results of the innovation are visible to others, overall policy environment, as well as the socio-economic characteristics of the adopter (Rogers, 1995; Chianu and Tsujii, 2004; Lee, 2005; Sidibe, 2005). The study looked at the role of the different technology dissemination pathways and tracking systems followed by NCARE and MC in influencing decisions to adopt, not to adopt, and dis-adopt the HGWFS. More specifically, it considered the implications in terms of: *selection criteria* used to identify potential adopters, facilitating equitable *access to information*; *tracking technology adoption* through periodic monitoring; and the overall effect on *perception* about the technology. The benefits of adopting the technology from the perspective of the two technology dissemination pathways and tracking systems in terms of their implications on household labor demand, economic benefits, and community empowerment through skill building were also assessed and are presented subsequently.

Selection criteria

Technology dissemination begins with identification of the right target group. At face value, both institutions used the same criteria to identify potential adopters of the technology, including (i) household size which was used as an indicator of the amount of greywater that can be generated, (ii) size of the home garden to ensure demand for treated greywater as it cannot be stored, (iii) connection to the municipal sewage line, and (iv) willingness of the household to adopt the technology. NCARE used these criteria to carefully and rigorously select 13 households in Madaba and Karak, while MC identified about 102 households through CBOs in Ma'an and Mafraq governorates. At the individual level, NCARE primarily focused on women members of selected households in recognition of the fact that they are in charge of water management at the household level. MC, on the other hand, relied on established CBOs, namely Petra Pottery Cooperative Society and Anakid Al-Khair Cooperative, to identify potential adopters from among their constituencies.

The validity of the general selection criteria is more or less confirmed by the results of our regression analysis on selected variables (Table 2). The results indicate that households who are not connected to the municipal sewer line and have large gardens with older and fruiting trees were more likely to adopt the technology at 1% significance level (Table 3).

Access to information

Lack of access to information is among the primary reasons for low rates of adoption of agricultural technologies. The two institutions used different pathways to transfer information to potential adopters of

Table 3. Binary regression results.

Variable		Score	df	Sig.
Step 0	Principle income	33.016	1	0.000
	Garden size	7.237	1	0.007
	Olive fruiting	17.155	1	0.000
	Olive avg. age	20.742	1	0.000
	Municipal sewer	31.530	1	0.000
	Household size	0.040	1	0.842
	Governorate	32.532	1	0.000
Overall statistics		99.204	7	0.000

the HGWFS. In the case of MC, KIIs and documentations provided by MC indicate that, information was mainly transferred through the selected CBOs in Ma'an and Mafraq. MC initially trained the heads of the CBOs on the benefits of the technology, installation and maintenance of the unit, as well as the potential costs of adoption. The knowledge was then transferred to potential adopters through trained heads of CBOs. The decision to adopt or not to adopt the technology thus mainly rested with the men, the official members of the CBOs. This was later confirmed by women from the community who attested to the fact during FGDs. Women were thus not afforded the same opportunity to learn about the benefits and responsibilities associated with the technology and receive the associated training. Further analysis of the survey data revealed that only 58% of the adopters reached by CBOs received installation-related training (Table 4), while 59% received management related trainings (Table 5), and about 40% of the adopters did not receive training on both.

On the other hand, analysis of information collected from NCARE, indicates that a series of trainings were provided for the women, beginning with the initial sensitization and installation procedures but lasting through the adoption and post-adoption phases. The training went beyond general benefits of the technology and offered training on effective management of water at the household level, including methods to improve the quality of the water before it leaves the house, monitoring the quality of the water in the treatment unit, as well as its management during irrigation.

Access to technology

Affordability is one of the major factors that affect adoption of agricultural technologies (Rogers, 1995). Prior to installing the treatment unit, households are also required to separate their plumbing system to allow the greywater to go into the treatment unit, and the black water into the cesspit; and to set up a drip irrigation system, which is also expensive. According to analysis of survey data, the main sources of income for households in Ma'an and Mafraq include military and government related jobs, pension, and self-employment. Military jobs accounted for about 46% of the household income, followed by government jobs (42%). Pension and self-employment offer minimal income opportunities for the community. In the case of Madaba and Karak income is mainly secured from pension with over 60% reported to be retirees. Other income sources include government jobs (24%), and to a lesser extent private businesses. NCARE was able to circumvent the challenge associated with the initial cost of adoption by bearing the full cost of required equipment, installing the HGWFS and drip irrigation, and covering associated maintenance costs. Adoption of the technology thus came at zero cost to the beneficiaries and adopters only had the responsibility of periodically cleaning the system. In the case of MC, the cost was covered through revolving credit facilitated by the CBOs. While both approaches managed to make the technology accessible and affordable to the users, they also present some serious challenges.

In the case of NCARE, provision of the technology at no cost created a sense of dependency wherein the beneficiaries of the technology as well as potential adopters expected NCARE to continue providing them with free but continuous support in monitoring and maintaining the system. This was evident in the FGDs held with both adopters and non-adopters of the technology in Madaba and Karak. While this may be feasible to do for a few households at the outset of technology dissemination, it is not a sustainable approach both in terms of its financial and associated labor implications to promote large-scale adoption of the technology. However, the approach also has its merits in that by seeing it through all the different stages of adoption, it clearly demonstrated the benefits of using the treatment unit thereby creating interest and positive perceptions among nearby communities.

In the case of MC, availability of credit created opportunities to afford adoption of the technology. Analysis of survey data indicated that, on average, a household borrowed about 600 Jordanian Dinars (JOD, about 840 USD based on exchange rate of November2015, JOD1=US$1.4) to be repaid within a

Table 4. Installation related training received by members of CBOs.

Variable		Frequency	Percent	Valid percent	Cumulative percent
	No	43	42.2	42.2	42.2
Valid	Yes	59	57.8	57.8	100.0
	Total	102	100.0	100.0	-

Table 5. Management related training received by members of CBOs.

Variable		Frequency	Percent	Valid percent	Cumulative percent
	No	42	41.2	41.2	41.2
Valid	Yes	60	58.8	58.8	100.0
	Total	102	100.0	100.0	-

period of 24 to 30 months. Subsequent evaluations by MC indicated a 100% loan repayment by CBO members who adopted the technology (Alulayyan, 2014). While this is a good success indicator for the revolving loan scheme, we found that it nonetheless masks the many challenges in the use and management of the treatment units, which are detailed subsequently

Technology 'tracking'

Technology 'tracking' includes among other things, advisory services that are provided to adopters of a technology to address unforeseen setbacks and to adapt the technology to fit existing socio-economic and biophysical conditions. In the case of MC, it was found that the HGWFSs were used for a maximum of two years before they were removed or dis-adopted by 86% of the respondents, even though households continued to pay their loans. Further analysis of surveyed data indicated that 66% of the respondents have completely uninstalled the unit, while 21% claimed that the infrastructure is still there though not in use. The high repayment rates, according to information solicited through FGDs, were thus not directly associated with the continued use of the technology, but more of a testament of members' commitment to their CBOs and the power of peer pressure. Further analysis of survey data indicated that the main reasons for dis-adoption were bad odor (76%), followed by clogging of the system and other technical difficulties (56%). KII with technical experts from NCARE revealed that these challenges could have certainly been avoided had there been an effective monitoring and technology tracking system in place to solve problems as they arise, use the challenges as teachable moments to build the capacity of the communities, and to provide essential feedback to researchers to fine tune the technology.

According to KII held with heads of CBOs, technology 'tracking' on the part of MC took the form of site visits and collection of water samples from selected units during the few months after adoption. But the adopters were not informed of the reasons for the test nor the results. In the case of adopters targeted by NCARE, FGDs with adopters revealed that frequent visits from NCARE and their participatory approach to involve adopters in the monitoring process had the opposite effect of building positive perception about the technology, the quality of the water generated, and to build local capacity. It was found that the women were quite knowledgeable about the technology (especially maintenance requirements in kitchens, such as separating grease and food particles in the water, and at the unit), and the challenges and benefits associated with its use.

Perception

Warranted and, at times, unwarranted perceptions of the technology also influenced decisions to adopt, not to adopt, and dis-adopt the technology. In this case, perceptions of the HGFWS technology were not always positive. It was found that causes for the negative perception mainly revolved around the odor of the treated water and often times related to cultural and religious views. While many variations of the technology tried to address this problem, it is important to also note that it is partially caused by lack of proper and regular cleaning on the part of the users. FGDs revealed that at times users of the technology merely used the system as a greywater disposal unit to reduce the inflow into cesspit tanks and hence the hefty costs associated with emptying the tank. For others the challenge related with ability to maintain the unit and fix malfunctions within the system. This was especially true in the case of adopters through local CBOs who did not receive adequate technical support.

It was also found through FGDs that assessment of the perception of users and non-users of the technology vary

across gender and communities. In the case of communities targeted by MC, male members of the community had relatively positive perception than women members of the community. The men highly appreciated the cost saving from pumping cesspit tanks. While this perception was also shared by the women, it was over-shadowed by the challenges associated with the smell which created problems for them with their neighbors and made the outside space of their home unusable. The smell also influenced their perception of the quality of the water and its fitness to irrigate olive trees. But despite these challenges the technology offered several benefits to the adopters.

Benefits of adopting the technology

Implications on labor demand

In addition to saving fresh water, we found that the HGWFSs offered several benefits for the household, including economic and labor benefits. However, we observed that the benefits were not 'gender neutral'. In terms of labor demand, the technology requires intensive labor during the installation phase of both the filtration and the drip irrigation system, and less so for periodic cleaning and maintenance of the unit. The major labor implication in terms of increasing/decreasing men or women's drudgery therefore depends on their roles, frequency, and cumbersomeness of the tasks involved in the use and management of the technology.

Analysis of the data collected indicated that men were predominantly responsible for installation, cleaning and maintenance of the unit, while women were primarily responsible for irrigating the olive gardens. In the case of NCARE's targeted adopters, women were responsible for both the post-installation cleaning the unit and irrigating the olive trees, while men took on the bulk of the responsibility during the installation and maintenance phases of the HGWFS. Moreover, in both cases of MC and NCARE women were responsible for the management of the quality of the water leaving the house, including the selection of less soapy dish-washing or laundry detergents, types of items they clean in the sink, and separating greasy dishes from non-greasy.

Adoption of the technology thus put additional labor demand for the men during the installation phase, particularly for those who cannot afford to hire outside labor, periodic but less-intensive demand for cleaning (in the case of MC targeted adopters), and for maintenance as needed. Women, on the other hand, took on the additional responsibility of cleaning the system (in the case of NCARE targeted adopters). However, in both cases women enjoyed reduced labor demand for irrigation as the greywater treatment unit is attached to an automated drip irrigation system. Prior to the installation of the unit, women had to manually irrigate the garden using buckets, often at night, when the municipal water is released. This was also confirmed by 90% of the non-adopters interviewed who reported that they irrigate their fields manually. While irrigating the field is predominantly a woman's task, in some cases it is a family shared responsibility. In this case, the labor saving combined with the quality of life improvement was appreciated by all members of the family. As stated by one interviewee:

"*In the past [before HGWFS installation], my husband and I got tired while we watered the plants. We had to share this duty as we have 25 olive trees. Now we are happy because we don't have to water the trees one by one. The children are more comfortable when water is supplied and they don't need to water trees. The GWT unit makes all household [members] more comfortable because we don't have to water plants [manually*]."

In general, it was found that women were quite appreciative of the technology, which not only reduced their drudgery associated with irrigating the olive trees, but gave them extra time to complete other household tasks or for leisure. Women targeted by NCARE confirmed during FGDs, that they did not consider cleaning the HGWFS tasking, but on the contrary consider its trade-off with the many benefits it offers quite substantial.

Economic implications

The economic benefits afforded by adopting the technology were manifold, including cost savings from emptying cesspit tanks; increased yield from their olives which had constant supply of water and hence increased production of and the likelihood to harvest olives and its byproducts, including olive oil; and for the women entrepreneurs' additional income from making and selling olive soaps. However, adopters of the technology in Ma'an and Mafraq governorates mostly used the treated greywater to irrigate ornamental plants and less so for their olive trees. This, as was found through FGDs, was due to lack of confidence in the quality of the water.

The cost of emptying the cesspit tank was quite hefty as the tank needed to be emptied quite frequently depending on the size of the tank and the amount of waste generated. According to the data analysis, the cost of emptying cesspit tanks ranged between 35 and 40 JOD (49 and 56 USD) per truck/month and could thus cost a household between 420 and 480 JOD/year or 588 and 672 USD/year. This is assuming that it is only done once a month, which is not always the case. Another cost saving was achieved through reduced demand for freshwater which households used to irrigate olive trees or garden trees. The trees were watered during days when water was released from the municipality, usually once a week during the summer season. The increase in

olive production, due to continuous irrigation of the trees, also had positive implications. Home processed olive oil and other related products saved the household money, and in the case of the women entrepreneurs generated additional income from making and selling olive-oil soaps.

Community empowerment

In addition to the awareness raising events held at the community level, specialized technical support was offered by both institutions to selected adopters of the technology. NCARE and MC both were active in raising awareness on water scarcity and in promoting the use of greywater to irrigate olive and other trees in home gardens. This was also evident in our discussions with, and survey of, non-adopters who served as a control group. We found that neighboring communities were fairly aware of the technology and the benefits it offers, though less so of its adverse effects. For instance, analysis of the data indicates that 7% of the adopters in Ma'an and Mafraq currently use untreated greywater to irrigate their trees. However, the figure is not very high as compared to the 65% of the non-adopters who are doing the same in the two governorates. In this regard, we see that the awareness raising efforts have succeeded in sensitizing adopters of the cons of directly using untreated greywater in their home gardens.

Technology tracking in the form of continuous follow-up on the part of NCARE, though unpractical for large-scale dissemination efforts, was quite useful in providing practical skills and on-the-job training. NCARE periodically monitored the quality of the water coming in and out of the system and frequently met with the adopters allowing them to address concerns together and more promptly. A good example of this participatory work, as reveled through FGDs, was the simple solution that was devised to address the odor problem. The women together with NCARE used plastic cups to cover the holes of the drip irrigation and buried the tube under the soil thereby minimizing exposure, odor, and physical contact with the treated greywater.

Potential for large-scale uptake of the technology

Technology diffusion involves several stages, including initiation, adoption, implementation, evaluation and integration (Rogers, 1983). Adoption on the other hand initially refers to the decision to adopt the technology among few individuals who had access to relatively more information and are willing to take the risk, followed by later adopters who are willing to adopt the technology based on evidence from the early adopters (Griliches, 1957; Mansfield, 1961). Both technology adoption and diffusion are thus processes with several steps, including awareness raising and initiation of interest, evaluation to ensure fit-for-purpose, and trying it at a smaller scale before confirming adoption (Beal et al., 1957).

The two dissemination pathways followed by MC and NCARE have resulted in achieving first level adoption among a selected few who had access to the information, and the financial and technical support (to varying degree) to do so. However, we found that the lack of technology 'tracking' on the part of MC and the dependency syndrome developed by NCARE's approach have not generated sufficient interest for late adopters. Moreover, the technical challenges associated with the upkeep were in fact the main reasons for dis-adoption of the technology for the majority of the adopters in Ma'an and Mafraq. However, another explanation for dis-adoption could be MC's approach to target CBO heads who in turn targeted male members of the household at the onset of technology adoption instead of targeting women in the household who deal with day-to-day water management before water leaves the house and maintenance of the system. This supports the case that dissemination pathways should conduct gender analysis to determine who does what in the household before promoting technologies for household adoption.

The body of literature on adoption-diffusion corroborates the challenges of re-gaining lost trust, and re-igniting interest in the same technology (Pannell et al., 2006). However, we find that despite the challenges associated with adopting the HGWFS, 92% of the adopters are still interested in adopting an improved version of the HGWFS that is adapted to addresses their concerns. The continued interest thus attests to the need for the technology and the benefits it renders. Moreover, of the total respondents 65% of adopters and over 90% of non-adopters were willing to pay an average of 5 JOD (7 USD) per month for periodic maintenance and advisory services. This could be an excellent opportunity to engage local youth through small businesses that provide technical and advisory services, including maintenance and cleaning of the treatment unit.

Therefore, based on the findings of this study, we propose that the most effective dissemination pathway should include gender sensitive selection criteria that offer equitable opportunities for both men and women to access information, credit, as well as advisory services during and after the initial adoption phase. The evidence from NCARE clearly demonstrated women's role in the maintenance and use of the technology, and thus the importance of targeting women with technical support. The dissemination pathway pursued by MC also had its merits in making the technology financially accessible, though not for all members of the community, but lacked the necessary support to adapt the technology to meet arising needs. The right dissemination pathway should thus have a well thought out feedback loop that connects users with technology providers and accounts for gendered differences and roles within households.

On a broader scale, large-scale adoption of the technology also requires a conducive policy environment. For instance, the low cost of water in the country poses a serious challenge. In addition to being cheap, the lack of a stringent system to collect monthly fees also serves as a disincentive to conserve water and opt for water saving technologies. For instance, we found that over 50% of the surveyed households in Ma'an and Mafraq have, on average, unpaid water bills ranging between 200and 300 JOD (between 280 and 420 USD). This is an exorbitant amount considering the fact that average water bill for a family ranges (depending on family size and availability of a garden) between 40 and 80 JOD/year. The arrears thus represent years of unpaid bills. We also found that payment of water bills did not improve substantially due to the cost savings from using the HGWFS. In this regard, only 14 and 35% of the survey respondents 'strongly agreed' and 'agreed' that the cost saving afforded them opportunities to catch up with their payments respectively. The main incentive for adopting the HGWFS was thus the cost saving from emptying cesspit tanks and not necessarily savings from water bills. This is generally true for households living in areas where a municipal sewer system is not present. Therefore, more needs to be done to raise awareness on water scarcity, the need to conserve water, and the potential of marginal waters, including greywater to meet certain demands. Policies that encourage the use of marginal water for agriculture through various incentives, and continually strive to build confidence in the quality and safety of treated marginal water will also be useful.

Conclusions

The comparative study identified several merits as well as challenges with the technology dissemination pathways and tracking systems used by the two institutions. It was found that the dissemination pathway used by MC offered greater opportunities for technology adoption, though it lacked the tracking system to discourage dis-adoption of the HGWFS in Ma'an and Mafraq. NCARE's choice of dissemination pathway provided limited opportunities for technology adoption but the tracking allowed adopters of the technology to continually and fully benefit from the HGWFS. Based on the findings of the study, the importance of technology 'tracking' and maintenance of adequate contact between users and researchers to build confidence and encourage late adopters to take on the technology was emphasized. It was also highlight that dissemination pathways are not gender neutral and thus call for conscious efforts to ensure that men, women, and youth can have equitable access to the technology and evenhandedly share in the benefits.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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