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ASSESSING THE EFFECTIVENESS OF PARTICIPATORY IRRIGATION MANAGEMENT APPROACHES TO IMPROVE WATER USE EFFICIENCY AND EQUITY IN GHANA

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Abstract: Participatory irrigation management (PIM) is widely used to improve water use efficiency and equity in irrigation systems. This study investigated the effectiveness of participatory irrigation management approaches to improve water use efficiency and equity in Ghana. A survey was conducted among farmers who use participatory irrigation management approaches and those who do not use such techniques. The results showed that farmers using participatory irrigation management approaches had higher water use efficiency and more equitable water allocation than farmers not using such approaches. In addition, the study found that various factors, including the level of farmer participation, the availability of water resources and the level of support from governmental and non-governmental organizations, influence the effectiveness of participatory irrigation management approaches. The study recommends that policy makers and stakeholders provide adequate financial and technical support for PIM initiatives to make water use more efficient and equitable in Ghana.

Keywords: *participatory irrigation management, water use efficiency, equity, Ghana*

INTRODUCTION

Water is a crucial resource for agriculture, which forms the backbone of the Ghanaian economy. However, the country's water resources are limited and their availability varies greatly in space and time.

This situation calls for efficient and equitable management of water resources to sustain agricultural production and ensure food security. Participatory irrigation management (PIM) is one possible solution to improve water use efficiency and equity in irrigation systems [1,2]. Such approaches involve the active participation of farmers in the management of irrigation systems, enabling them to use water more efficiently and equitably.

Participatory Irrigation Management (PIM) is an approach in which farmers are involved in all phases of irrigation development through to operation and maintenance. The aim of PIM is to manage water in a decentralized manner while giving the local community an important role in its management.

The basic principles of sustainable PIM include the participation of irrigation users, decentralization of management, empowerment of farmers, development of local institutions and the promotion of equity and gender sensitivity. It is based on the realization that the success of irrigation systems depends not only on the technical aspects of the system, but also on the social and institutional dimension. The PIM approach aims to empower farmers and other stakeholders to actively participate in the decision-making process, planning, operation and maintenance of irrigation systems. The PIM approach can take different forms depending on the specific context and objectives of the irrigation system. Some common characteristics of PIM approaches are:

1. Decentralization: the decentralization of decision-making authority and management responsibility from government agencies to local water user associations or committees.
2. Capacity building: Providing training and technical assistance to farmers and other stakeholders to improve their knowledge and skills in irrigation management.
3. Collective action: Promoting collective action among farmers to jointly manage water resources and infrastructure.
4. User fees: The collection of user fees to finance the operation and maintenance of irrigation systems. These fees are administered by local water user associations or committees.
5. Conflict resolution: The development of mechanisms to resolve conflicts and disputes between users and between users and managing authorities.

The PIM approach has already been implemented in many countries and has shown promising results in improving the efficiency and sustainability of irrigation systems [3, 4]. However, the success of PIM depends on the willingness of all stakeholders to cooperate and on the availability of resources to support the process. Despite the potential benefits of participatory irrigation management approaches, their effectiveness in improving water use efficiency and equity in Ghana has not been adequately researched [5, 6 and 7]. The aim of this study was therefore to investigate the effectiveness of participatory irrigation management approaches in improving water use efficiency and equity in Ghana.

MATERIALS AND METHODS

This study used a survey method to collect data from farmers who use participatory irrigation management approaches and those who do not use such approaches using a stratified random sampling technique.

A structured questionnaire was used to collect data on water use efficiency, equity, and other relevant variables.

The sample size was determined using a formula for estimating sample size in survey research. A total of 200 farmers were selected from four irrigation schemes in Ghana, with 100 farmers from schemes using participatory irrigation management approaches and 100 farmers from schemes not using such approaches.

Scheme A: This is one of the largest irrigation schemes in Ghana, covering an area of about 3,000 hectares in the Upper East Region. It was established in the 1960s and is primarily used for rice cultivation. The scheme has undergone several management reforms, including the introduction of participatory irrigation management approaches. The study surveyed 50 farmers from this scheme to gather data on their water use efficiency, equity, and other relevant variables. The farmers actively participated in decision-making processes, management activities, and maintenance of the irrigation system.

Scheme B: In contrast to Scheme A, this irrigation scheme did not utilize participatory irrigation management approaches. The study also surveyed 50 farmers from this scheme to compare the data with Scheme A. Farmers in Scheme B have experienced more top-down decision-making and limited involvement in the management and maintenance of the irrigation system.

Scheme C: This irrigation scheme is another example where participatory irrigation management approaches were implemented. The study gathered data from 50 farmers within this scheme to assess water use efficiency, equity, and other relevant variables. Similar to Scheme A, farmers in Scheme C actively participated in decision-making processes and had a greater role in managing and maintaining the irrigation system.

Scheme D: The fourth irrigation scheme examined in the study did not adopt participatory irrigation management approaches. Data was collected from 50 farmers in this scheme to compare it with Scheme C. Farmers in Scheme D may have experienced less involvement in decision-making and a more centralized management approach.

Data were analyzed using descriptive statistics and standard deviations.

RESULTS AND DISCUSSION

The results show that PIM approaches positively impact water use efficiency and equity in irrigation systems. The farmers who participated in PIM activities reported higher water use efficiency and more equitable water distribution among farmers than those who did not participate in PIM activities.

Table 1 shows the characteristics of the farmers who adopted the Participatory Irrigation Management (PIM) approach compared to those who did not adopt the approach. Out of the 200 farmers surveyed, 100 used PIM while the other 100 did not use the approach.

Table 1. Demographic characteristics of farmers who use and those who do not use participatory irrigation management approaches

Characteristic	PIM Farmers (n=100)	Non-PIM Farmers (n=100)
Gender (Male, Female)	65, 35	70, 30
Age (years)	45.6 ± 5.7	47.2 ± 6.3
Education level (No. of years)	7.8 ± 1.4	6.4 ± 1.8
Land size (acres)	4.5 ± 2.1	3.8 ± 1.9
Irrigation water source (Surface, Groundwater)	50, 50	60, 40

The gender distribution of PIM farmers was 65% male and 35% female while non-PIM farmers had a gender distribution of 70% male and 30% female. The mean age of PIM farmers was 45.6 ± 5.7 years, while that of non-PIM farmers was 47.2 ± 6.3 years. On average, PIM farmers had a higher education level of 7.8 ± 1.4 years compared to non-PIM farmers, with an education level of 6.4 ± 1.8 years. PIM farmers had a larger land size of 4.5 ± 2.1 acres than non-PIM farmers, with a land size of 3.8 ± 1.9 acres. The irrigation water sources for PIM and non-PIM farmers were evenly split between surface and groundwater for PIM farmers, while non-PIM farmers had a higher reliance on surface water.

The results are consistent with previous studies that have shown that PIM farmers tend to have larger land sizes and higher education levels than non-PIM farmers [8,9 and 10]. However, the gender distribution of PIM farmers observed in this study differs from the results of a study conducted by Narayanan [11] in Rwanda, which found that the majority of PIM farmers were male. This could be attributed to cultural and contextual differences between Ghana and Rwanda.

Table 2. Water use efficiency of farmers using and not using participatory irrigation management approaches

Farmer Group	Mean WUE (kg/m ³)	Standard Deviation
PIM Farmers (n=100)	0.63	0.08
Non-PIM Farmers (n=100)	0.47	0.11

Table 2 shows the mean water use efficiency (WUE) of PIM and non-PIM farmers in Ghana. The WUE for PIM farmers was 0.63 kg/m^3 with a standard deviation of 0.08, while the WUE for non-PIM farmers was 0.47 kg/m^3 with a standard deviation of 0.11. The difference in mean WUE between PIM and non-PIM farmers was statistically significant ($p < 0.05$), indicating that PIM farmers had higher water use efficiency compared to non-PIM farmers.

The results are consistent with previous studies that have shown that PIM can improve water use efficiency (Yan & Wang, 2019). A study conducted by Gaihre et al. [12] in Nepal found that PIM farmers had a 27% higher WUE compared to non-PIM farmers. Another study by Omrani. [13] in Iran found that PIM improved WUE by up to 25%. The higher WUE observed among PIM farmers could be attributed to the fact that PIM provides farmers with greater control over irrigation water management, which enables them to optimize water use and reduce wastage. PIM also encourages the adoption of modern irrigation technologies and techniques that can improve WUE. These findings suggest that PIM can be an effective approach for improving WUE in irrigation agriculture.

Table 3. Equity in water distribution among farmers using and not using participatory irrigation management approaches

Farmer Group	Mean WDE (%)	Standard Deviation
PIM Farmers (n=100)	67.2	9.6
Non-PIM Farmers (n=100)	55.6	13.4

Table 3 shows the mean water distribution equity (WDE) of PIM and non-PIM farmers in Ghana. The WDE for PIM farmers was 67.2% with a standard deviation of 9.6, while the WDE for non-PIM farmers was 55.6% with a standard deviation of 13.4. The difference in mean WDE between PIM and non-PIM farmers was statistically significant ($p < 0.05$), indicating that PIM farmers had more equitable water distribution compared to non-PIM farmers.

These findings are consistent with previous studies that have shown that PIM can improve water distribution equity [14,15]. A study conducted by Jahan et al. [16] in Bangladesh found that PIM improved water distribution equity by up to 20%. Similarly, a study by Shakya et al. [17] in Nepal found that PIM significantly improved water distribution equity. The higher WDE observed among PIM farmers could be attributed to PIM promoting participatory decision-making among farmers, ensuring that water is distributed more equitably among all users. PIM also promotes the establishment of water user associations (WUAs) which can help to manage and distribute water more fairly among farmers.

Table 4. Factors influencing water use efficiency among farmers using participatory irrigation management approaches

Factors	PIM Effectiveness
Level of Farmer Participation	High
Access to Technical Assistance	High
Availability of Irrigation Water	High
Size of Irrigated Land	High
Farmer Education Level	Medium-High
Contin. Table 4.	
Gender of Farmer	Medium
Farming Experience	Medium
Farm Size	Low
Farmer Age	Low
Distance to Market	Low

Table 4 shows the factors affecting the effectiveness of PIM in enhancing water use efficiency and equity in Ghana.

The level of farmer participation was found to have a high impact on PIM effectiveness, as farmers who actively participate in the management and decision-making processes are more likely to adopt sustainable irrigation practices and distribute water more equitably [18]. Access to technical assistance was also found to have a high impact on PIM effectiveness, as farmers who received technical support and training on irrigation management were more likely to adopt best practices and increase water use efficiency [19]. Availability of irrigation water was another important factor affecting PIM effectiveness, as farmers who had reliable access to irrigation water were able to manage their water use more efficiently and equitably [20]. Other factors such as the size of irrigated land, farmer education level, gender of the farmer, farming experience, farm size, farmer age, and distance to market were found to have a moderate to low impact on PIM effectiveness.

Table 5. Factors influencing equity in water distribution among farmers using participatory irrigation management approaches.

Factors	PIM Farmers	Non-PIM Farmers
Water Use Efficiency	78%	62%
Equity in Water Distribution	0.70	0.50

Table 5 shows a comparison of water use efficiency and equity in water distribution between PIM and non-PIM farmers in Ghana.

The results indicate that PIM farmers had higher water use efficiency compared to non-PIM farmers, with an average efficiency of 78% for PIM farmers and 62% for non-PIM farmers. This finding is consistent with the results of a study by Renner et al. [21], which showed that PIM approaches can significantly improve water use efficiency in irrigation systems. Regarding equity in water distribution, PIM farmers also had a higher level of equity than non-PIM farmers, with an average equity index of 0.70 for PIM farmers and 0.50 for non-PIM farmers. This suggests that PIM approaches can help promote more equitable water distribution among farmers, leading to improved social and economic outcomes [22].

Table 6. Association between availability of water resources and water use efficiency among farmers using participatory irrigation management approaches

Factors	Description
Level of farmer participation	The extent to which farmers are involved in decision-making processes and the management of the irrigation systems.
Access to resources	The availability of financial, technical, and institutional resources to support PIM initiatives.
Institutional support	The extent to which government policies and programs support PIM initiatives.
Farmer training	The provision of training and capacity building programs to enhance farmers' knowledge and skills in irrigation management.

Table 6 summarizes the factors that influence the effectiveness of PIM approaches in enhancing water use efficiency and equity in water distribution.

The study found that the level of farmer participation is crucial in determining the effectiveness of PIM approaches. When farmers are actively involved in the decision-making process and the management of irrigation systems, they tend to have a higher sense of ownership and responsibility, which leads to improved water use efficiency and equity in water distribution [23, 24]. Access to resources, including financial, technical, and institutional resources, was found to be another critical factor in determining the effectiveness of PIM approaches. When farmers have access to adequate resources, they can invest in modern irrigation technologies, which can improve water use efficiency [22]. Institutional support, including government policies and programs, was also found to be an important factor in supporting the adoption and effectiveness of PIM approaches [22].

Finally, the study found that providing farmer training and capacity building programs was a critical factor in enhancing the effectiveness of PIM approaches. Farmers who received training on modern irrigation technologies and water management practices were found to be more likely to adopt PIM approaches and improve water use efficiency [22].

The results also showed that the level of farmer participation, availability of resources, technical capacity of farmers, access to credit, institutional support, and farmer motivation and interest all positively influence the effectiveness of PIM approaches. Several studies have highlighted the importance of farmer participation in PIM approaches. For example, a study by Shah et al. [25] found that active participation of farmers in water management committees can enhance the effectiveness of PIM approaches in improving water use efficiency and equity. Similarly, Huang et al. [26] found that increasing farmer participation in water management decision-making can lead to more equitable water distribution. Farmers' availability of resources and technical capacity also play an important role in the effectiveness of PIM approaches. Adequate resources, such as water supply, infrastructure, and equipment, are essential for effective irrigation management [22].

Similarly, farmers must have the technical skills and knowledge to effectively manage irrigation systems [21]. Access to credit can also facilitate the adoption of PIM approaches by providing farmers with the financial resources needed to invest in irrigation infrastructure and technologies [27]. Institutional support, such as policies and regulations that promote PIM approaches, can also enhance their effectiveness [22]. Finally, farmer motivation and interest in PIM approaches can influence their effectiveness. A study by Zhou et al. [28] found that farmers motivated to participate in PIM approaches were more likely to adopt sustainable irrigation practices.

CONCLUSION

This research study presents empirical findings about the efficacy of participatory irrigation management strategies in improving both water utilization efficiency and fairness in Ghana. The research revealed that farmers who employed participatory irrigation management strategies had greater water usage efficiency and more equitable water distribution in comparison to their counterparts who did not adopt these techniques. Moreover, the study found that various factors, including the level of farmer participation, the availability of water resources, and the level of support from government and non-governmental organizations influenced the effectiveness of participatory irrigation management approaches.

Based on the aforementioned findings, it is recommended that efforts be made to promote participatory irrigation management systems in Ghana, accompanied by the provision of requisite assistance. These measures are deemed required in order to boost both water usage efficiency and equity within the country.

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**PROCENA EFIKASNOSTI PRISTUPA PARTICIPATIVNOG UPRAVLJANJA
NAVODNJAVANJEM ZA POBOLJŠANJE EFIKASNOSTI
I PRAVIČNOSTI KORIŠĆENJA VODE U GANI**

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Apstrakt: Participativno upravljanje navodnjavanjem (PIM) se široko koristi za poboljšanje efikasnosti korišćenja vode i pravičnosti u sistemima za navodnjavanje. Ova studija je istraživala efikasnost participativnih pristupa upravljanja navodnjavanjem kako bi se poboljšala efikasnost korišćenja vode i pravičnost u Gani.

Sprovedena je anketa među poljoprivrednicima koji koriste participativno upravljanje navodnjavanjem i onima koji ne koriste takve tehnike.

Rezultati su pokazali da su farmeri koji koriste participativne pristupe upravljanja navodnjavanjem imali veću efikasnost korišćenja vode i pravičniju alokaciju vode od farmera koji ne koriste takve pristupe. Pored toga, studija je otkrila da različiti faktori, uključujući nivo učešća farmera, dostupnost vodnih resursa i nivo podrške vladinih i nevladinih organizacija, utiču na efikasnost participativnog pristupa upravljanju navodnjavanjem.

Studija preporučuje da kreatori politike i zainteresovane strane obezbede adekvatnu finansijsku i tehničku podršku za inicijative PIM-a kako bi korišćenje vode u Gani učinilo efikasnijim i pravičnim.

Ključne reči: participativno upravljanje navodnjavanjem, efikasnost korišćenja vode, pravičnost, Gana

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