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Farmer Involvement in Irrigation Agriculture: Evidence from the Anambra-Imo River Basin Irrigation Scheme, Nigeria

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Abstract

This study was conducted in the Anambra catchment of the Anambra-Imo River Basin Development Authority(AIRBDA), Nigeria. The aim was to analyse the involvement of farmers in irrigation agriculture as a key component of public agricultural project performance. A multi-stage sampling procedure was adopted in selecting ninety(90) farmers from the catchment of the AIRBDA. Descriptive statistics provided initial insight into operational and structural characteristics, while relevant visualizations were produced using Python and Excel. The Logit estimate identified factors influencing farmers' involvement in the irrigation schemes, thereby offering empirical evidence relevant for project appraisal and management. Results showed that 15.6% of farmers reported non-participation, while about 84.4% were active participants in the scheme. The estimated model reported a Wald chi² of 39.65 and a log pseudolikelihood of –281.37084. Farm experience, household size, major occupation, farm income, and membership in the Water Users Association (WUA) significantly influenced farmers' involvement in the irrigation scheme. It recommends strengthening Participatory Irrigation Management (PIM) systems, whereby farmers manage routine water allocation, while the River Basin management provides technical oversight, with a member of the Water Users Association as a part of its team.

Keywords

Irrigation scheme, project, involvement, farmers, logit model, Anambra-Imo-River-Basin.

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Introduction

The River Basin Development Authorities (RBDAs) play a pivotal role in the agricultural development of every country, particularly through its irrigation project investments. As a public agricultural project, they are crucial in enhancing agricultural productivity, mitigating the effects of seasonal variations in rainfall, and ensuring food security (Abah and Nankiel, 2019; Christopher, 2016). However, the effectiveness of these irrigation schemes depends in part on the participation of the farmers who utilize them. Understanding the dynamics of farmer involvement in these schemes is essential for optimizing outcomes and ensuring sustainable agricultural development. Various factors, ranging from socio-economic, structural to institutional and environmental factors influence the engagement of the farmers in the irrigation project of the Anambra Imo River Basin Development Authority (AIRBDA).

One significant aspect influencing farmer involvement is the availability of the Water Users Associations (WUAs). These associations, which serve as cooperatives, are platforms for collective decision-making, resource management, and conflict resolution among farmers utilizing irrigation facilities in the River Basin Development Authorities (Aarnoudse et al., 2019). The effectiveness of the WUAs in fostering farmer participation hinges on factors such as leadership quality, transparency in decision-making processes, and equitable distribution of water resources.

Further, many farmers are poor and subsistent, therefore the cost of irrigation services provided

by the AIRBDA can influence farmers' decisions to participate in the schemes and deter small-scale farmers with limited financial resources from accessing irrigation facilities, even if those farmers belong to the Water User Associations. It is equally interesting to note that regardless of the long practice of irrigation farming in the River Basin Development Authorities, most farmers still find it difficult to identify the irrigation type that is suitable for a particular crop. This education or awareness creation should be the role of the extension agents (Raji et al., 2024) or technical staff of the River Basins. Sadly, access to extension services tend to be limited.

There is equally limited access to water in some of the projects. This development has hampered all year-round production in some sites. Despite the huge amount of funds dedicated to the irrigation scheme and the efforts of the River Basin Development Authority management, farmer involvement remains a problem in most areas. Although a large proportion of the farmers under the scheme have many years of farming experience, quite a number of them depend on seasonal production occasioned by rainfall.

This research, therefore, aims at identifying the types of irrigation systems available in the area, the level of involvement of the farmers in these schemes, and the factors that affect farmer involvement. These issues are pertinent to providing the direction for this study and pivotal to developing policy options that would be beneficial to the River Basin and the farmers.

Materials and methods

This study was carried out in the Anambra catchment of the Anambra-Imo River Basin Development Authority, AIRBDA Nigeria. Anambra is in the Southeastern part of Nigeria, with a projected population of about 5.95 million (National Beareau of Statistics (NBS) (2022).

It is on the latitude (6.2209° N) and longitude (6.9370° E) of the equator. It has a tropical wet and dry season, with a yearly average temperature of 28.99°C (84.18°F). Anambra typically receives about 2,553mm/year mean precipitation and has about 150-180 rainy days annually (Omoja et al., 2021). Agriculture is an important part of the economy of Anambra. The AIRBDA derived its name from the Anambra River and Imo River, which flow through the area and are tributaries of the famous River Niger.

A multi-stage sampling technique was used for the study. In the first stage, Ayamelum Local Government Area (LGA), which is the host L.G.A. of the AIRBDA irrigation scheme, was purposely selected because of the irrigation activities of the River Basin that take place in this region. In the second stage, three communities—Omor, Umumbo, and Umuerum—were purposely selected from the Ayamelum LGA due to a large proportion of farmers in the area, who are involved in various types of cropping activities. The third stage involved the random selection of 30 crop farmers from each of the three communities, giving a total of 90 farmers, who were investigated in this study. The list of the crop farmers was obtained from the management of the AIRBDA.

The data obtained were analyzed, using descriptive statistics such as means, frequencies, and percentages. Specifically, doughnuts, clustered bars, and boxplots were used to visualize the data and draw insights on the level of involvement, type of irrigation used by farmers, and total and irrigable land cultivated by the farmers.

Also, the logistic regression model was employed to analyze involvement in irrigation agriculture by the farmers.

The implicit functional form of the logit model employed is stated, as:

$$Y = \text{Ln}\ (Pi/1\text{-}Pi) = \alpha_0 + \alpha_1 X_1 + \ldots + \alpha_k X_k + ei \quad (1)$$

Explicitly, the model is specified as:

$$Y = Ln(Pi/1\text{-}Pi) = \alpha_0 + \alpha_1 AGE + \alpha_2 EXT + \\ + \alpha_3 SIZ + \alpha_4 EDU + \alpha_5 EXP + \alpha_6 CST + \\ + \alpha_7 HHS + \alpha_8 MRJ + \alpha_9 FINC + \alpha_{10} WUA \quad (2)$$

Where Y is the dichotomous dependent variable, which can be explained as $Y = 1$ if the farmer is involved in irrigation agriculture and 0 otherwise. The *Xs* are as defined below:

- *AGE* = Age of farmer (measured in number of years a farmer has lived)
- *EXT* = Extension agent (dummy, farmer has access to an extension agent = 1, otherwise = 0)
- *SIZ* = Farm Size (indicates the size of the farmer's land in hectares)
- EDU = Education (number of years of formal education in years)
- *EXP* = Experience (years of experience in farming)
- *CST* = Cost of irrigation services (in Naira)

- *HHS* = Household Size (number of people living and depending on the farmer for their livelihood)
- *MRJ* = Major occupation (dummy, farming = 1, otherwise = 0)
- *FINC* = Farm income (income from farming (in Naira)
- *WUA* = Membership of Water User Association (if member, 1; 0 = otherwise)

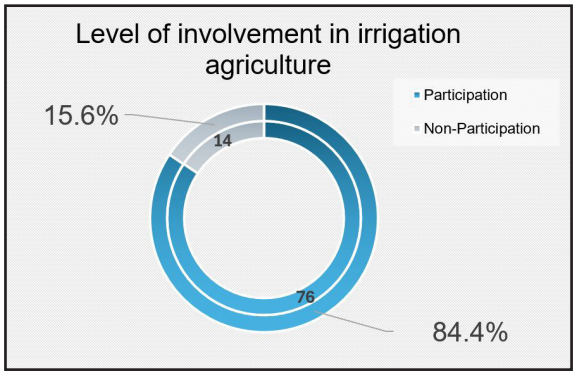
Results and discussion

Operational and structural characteristics of respondent farmers

Results are presented for selected operational and structural characteristics of the farmers such as level of involvement in irrigation agriculture, irrigation methods and usage by farmer, total and irrigable land area cultivated and irrigation type and usage by gender.

Level of involvement in irrigation agriculture

The Figure 1 below shows percentage participation and non-participation in the scheme by the farmers. Fifteen point six percent of the farmers are not involved in irrigation agriculture, while 84.4% of the farmers are fully engaged in irrigation activities. Many of the farmers in the study area were therefore involved in one form of irrigation activity or another. This statistic corroborates the study carried out by Adekunle (2015), where about 80 percent of farmers participated in irrigation farming.



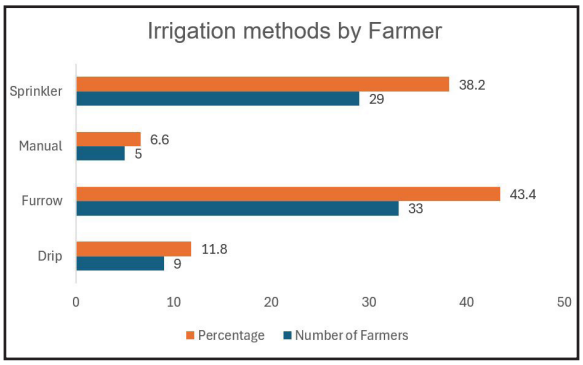
Source: Field survey data, 2023

Figure 1: Level of involvement in irrigation agriculture.

Saddiq et al. (2025) in examining impact of participation in irrigation projects on the livelihood of small-scale rice farmers in selected states of North-Western Nigeria reported 37% and 43.8% of participating and non-participating farmers being within the age range of 41-50 years. Also, 84.6% and 97.7% of the participating and non-participating farmers were of male gender, while 94.3% and 96.9% of participants and non-participants were married. These perecentages reveal that a good number of farmers where involved in irrigation agriculture at the study location. Irrigation has generally been reported to improve yield, and farmer practice of irrigation agriculture is great incentive to economic development.

Irrigation methods and usage by farmer

Irrigation types prevalent in the area and farmer usage were examined, using clustered bar as presented in the Figure 2 below. The bar reveals that 38.2 percent of the farmers in the region make use of sprinkler irrigation, while 11.8 percent make use of drip irrigation. Furthermore, only about 6.6 percent of the farmers use a manual method of irrigation, while 43.4 percent use the furrow method. This result corroborates the study by Wicaksono (2024), which reveals that the majority of the respondents in the study area practised surface irrigation, which accounted for 57 percent of the types of irrigation considered in the study. Further, 26 percent of the farmers in that study made use of sprinkler, while 13 percent used the drip irrigation method.



Source: Field survey data, 2023

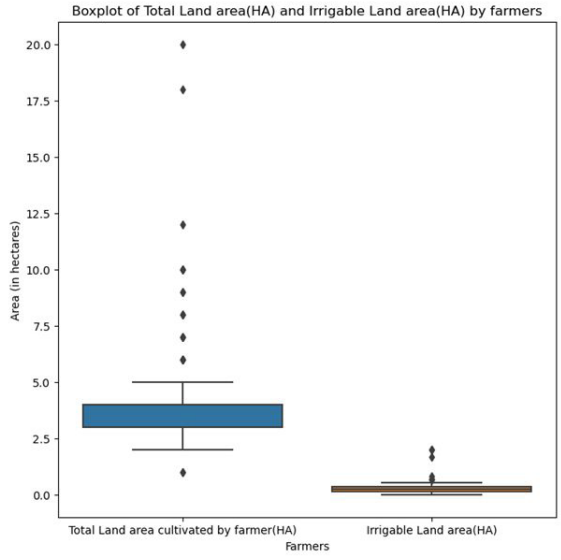
Figure 2: Irrigation methods used by farmers.

Ballas (2024) in the book "Irrigation Methods" outlined several irrigation methods. Some of these are traditional methods, such as surface irrigation, which rely on gravity to distribute water. This method is somewhat cost-effective. Modern techniques cited in the book are drip irrigation and sprinkler systems which have been use to revolutionized water management. Other advanced methods of irrigation are subsurface irrigation and automated precision irrigation systems, which leverage technology to optimize

water distribution based on soil moisture and crop needs (Balas et al., 2024).

Total land area and irrigable land area cultivated by farmers

To further examine farmer participation in irrigation activities within the catchment of Anambra-Imo River Basin, the total land area cultivated by each farmer and the corresponding irrigable land were examined, using boxplot (see Figure 3 below) Large variabilities were observed in total area of land owned and cultivated by the farmer compared to the available irrigable land as shown in the outliers. Total land area may have more variability due to land quality, topography (Smith, 2009), or historical use, while irrigable land area may be more consistent among farmers, most especially if the farmers have similar access to water sources or irrigation infrastructure. Variations in total land area could arise from differences in landownership or tenure rights. The adoption of improve agricultural technologies, most especially among small holder farmers would likely increase with farm size (Ebrahim and Toy, 2024).



Source: Field survey data, 2023

Figure 3: Boxplot showing total land area and irrigable land area by farmer.

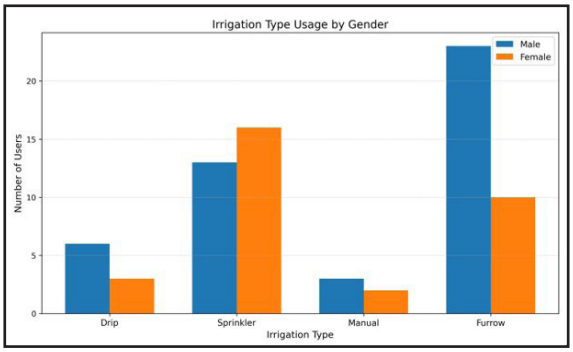
Irrigation type and usage by gender

The Table 1 and Figure 4 shows that the sprinkler and furrow irrigation methods are mostly used by both genders. More male farm owners tend to make use of the furrow method. Manual irrigation was least used by both genders. The sprinkler irrigation is the second most used method. The method simulates rainfall and it is perhaps preferred for its moderate efficiency and crop types cultivated by the farmers in the region (Shankar et al., 2015). Furrow is the most common among the male crop farmers and the second most used among the female farmers. This method, which involves making furrows along farm fields and channeling water through them, might be cost-effective to operate. However, the notable gender difference may be because it is somewhat labor-intensive thereby attracting more males than females (Radovic-Markovic et al., 2020). Gender power relations in irrigation resource access among farmers remains a critical concern (Mwalyigial et al., 2025).

	Percentage Usage by Gender			
Irrigation type	Male	Percentage	Female	Percentage
Drip	6	13.3	3	9.7
Sprinkler	13	28.9	16	51.6
Manual	3	6.7	2	6.5
Furrow	23	51.1	10	32.2
Total	45	100	31	100

Source: Field survey data, 2023

Table 1: Gender distribution of farmers by irrigation methods used.



Source: Field survey data, 2023

Figure 4: Usage of irrigation types by gender.

Determinants of involvement in irrigation agriculture

The estimated determinants of participation in irrigation agriculture are summarized and presented in Table 2 below: The table reveals that farming experience, Household size, major occupation of the farmer, farm income, being a member of the Water Users Association (WUA) were significant variables that influenced particicpation or involvement in irrigation agriculture. The regression result reported a Wald chi² of 39.65 and a log pseudolikelihood

Variable	Co-efficient	Standard Error	Z	P>|z|
Experience in Farming	.0080661	.0035	2.30	0.021[2]
Household Size	-.0399064	.01785	-2.24	0.025[2]
Major Occupation	-.2292222	.05423	-4.23	0.000[1]
Farm Income	5.64e-08	.00000	2.01	0.044[2]
Member of WUA	-.2150519	.06218	-3.46	0.001[1]
Cost of irrigation	1.74e-07	00000	-1.65	0.100
Age	-.0015055	.00315	-0.48	0.633
Extension Services	.0111409	.01478	0.75	0.451
Farm Size	0104183	.00795	-1.31	0.190
Education	.0077013	.0047	1.64	0.102
No. of observations = 90				
Wald chi^2 (10) = 39.65				
Log pseudolikelihood = -281.37084				

Note: [3, 2, 1] statistically significant at 10%, 5% and 1% respectively

Source: Field survey data, 2023

Table 2: Estimated determinants of involvement in irrigation agriculture.

of -281.37084, providing insights into the model's fitness and overall significance.

Farming experience is significant at a 5% level and positively signed. This implies that there is a direct positive relationship between experience in farming and participation in irrigation schemes by the farmer. This is in line with a prior expectation, as the more experienced the farmer is, the more likely he will be exposed to farming technologies and the more receptive to new innovations. A unit change in years of farm experience will lead to a 0.8% change in the probability of participation in irrigation farming. The study corroborates the work of Ainembabazi and Mugisha (2014), which posited that farming experience is useful in the early stages of adoption of a given technology when farmers are still testing the potential benefits of the technology. The study further emphasized that gradual advances in technology development and continuous retraining of the farmers are very essential for sustainable and lasting adoption of agricultural technologies for certain crops. In an earlier study carried out by Dauda et al. (2009), to assess the roles of irrigation farming in the millennium development goals, the result of the study showed that irrigation experience was among the variables found to have significant effects on profit realized from irrigation farming. This would not have been possible without the farmer being involved in the farming activities, leading to years of experience.

Household size is significant at the 5% level and is negatively signed. This implies that there is an inverse relationship between household size and involvement in irrigation agriculture. In larger households, resources such as land, labor, and capital are most of the time spread thinly among family members. As a result, households may prioritize subsistence activities that require less capital investment (Xie, 2017; Kolawole et al., 2020), such as rainfed agriculture, over engagement in irrigation farming that entails additional costs. Furthermore, a larger household may have more members available for agricultural labour, thereby reducing the need for external irrigation infrastructure to enhance productivity. As a result, these households may rely on more traditional farming methods that do not require irrigation. A unit change in the number of farmers household size will lead to a 3.9% change in the probability of involvement in irrigation agriculture. This result differs from the findings of Afodu et al. (2021), who revealed that a larger household size may lead to more adoption of the modern technologies in plantain production, which could translate into increased productivity of the plantain farmers. However, it corroborates the findings of Olumba (2014) and Mengiste et al. (2025), who found that household size influences farming decisions on management practices.

Major occupation is significant at the 1% level and is negatively signed, reflecting an inverse relationship between the major occupation

of the farmer and participation in irrigation agriculture. A unit change in the main occupation will lead to a 22.92% change in the probability of involvement in irrigation farming. The distances from water sources and markets for products, as well as the financial costs associated with irrigation activities, can discourage a farmer from being involved in irrigation activities, especially if their main occupation requires significant time and resources elsewhere. Yin et al. (2016) viewed this differently in his attempt to examine the impacts of off-farm employment on irrigation water efficiency (IWE), an attribute of participation, with a set of household level data collected in Hebei Province in North China. Findings from thee study reveals that households with higher number of labourers working off-farm seem to achieve a higher IWEs.This implies that the higher the number of households involved in non-farm income activities, which is most likely a major occupation due to their number, the more efficient they are in irrigation water use. This sub-study contradicts the result of our findings which is an inverse relationship. Further, off-farm employees tend to achieve higher IWEs, while those with more elderly people as labourers and those with larger farms are associated with lower IWEs (Yin et al., 2016). The study further corroborates that of Rustinsyah (2019) which posited that water management in Bengawan Solo river basin, Indonesia is basically managed by businessmen rather than the WUA due to limited capital. This reflects a clear positive relationship between a major occupation and participation in irrigation scheme.

Farm income is significant at the 5% level with a positive sign. This implies that a unit change in farm income will lead to a 0.00000564% change in the probability of involvement in irrigation agriculture. Farm income has a positive relationship with involvement in irrigation agricultural activities because engaging in irrigation activities can significantly impact household income. Research indicates that participation in irrigation can lead to increased household income and crop production. This corroborates the work of Gadisa and Gebrerufael (2021). This positive relationship underscores the importance of irrigation in improving welfare and agricultural productivity (Yusuf et al., 2023). Further evidence by Li (2020) in a study on impact of access to irrigation on rural incomes and diversification in China, posited that, access to irrigation has a significant and positive relationship on rural incomes and diversification. Attributes and treatment effect of irrigation access were to increase farm income, household income and income diversification by 14, 10 and 107% respectively. Findings from the study revealed that irrigation effects on diversification and rural incomes are diverse and multifarious between small and large scale farmers and between gender. Irrigation generally play a crucial role in augmenting household farm income and improve livelihoods of farmers

WUA membership is significant at the 1% level and negatively signed. This result shows an inverse relationship between membership of WUA and participation in irrigation schemes. A unit change in membership will lead to a 21.5% change in the probability of involvement in the irrigation agriculture. The negative coefficient for membership of a WUA is a pointer that being a member of a WUA has an indirect relationship with participation in irrigation activities. This is contrary to a priori expectations and could be due to various factors such as conflicting interests, association dues, lack of perceived benefits, or challenges in decision-making processes, within the association or the management of the river basin (Nyamulo and Pastory, 2024). This finding goes contrary to the work of Gadisa and Gebrerufael (2021)), whose results showed that cooperative membership has a positive and statistically significant effect on technology adoption. Suraj (2025) in his work on Membership of Water User Associations and food security reveal a significant relationship between being a member of WUA and participation in supplementary irrigation and draught index insurance initiatives. Other factors that had significant effect of WUA were age, marital status, access to extension services, farm size and the asset aspiration gap (Suraj, 2025). The study advocates development policies that strengthens existing WUAs through inclusive approaches that addresses food seccurity challenges.

Cost of irrigation shows a borderline involvement of farmers in irrigation agriculture. Even though this effect is not statistically significant, the marginal outcome ($P = 0.10$) suggests that irrigation costs may still play a role, though weak, in affecting farmers involvement in irrigation agriculture. The sign of the coefficient is positive indicating that as irrigation cost increases, involvement in irrigation agriculture equally increases, although the evidence is not

strong enough to draw definitive conclusion. The maginal outcome may further be a reflection of the reality that farmers sometimes rely on informal water sharing arrangements (Manzoor Qadir, 2007; Tang et al., 2025) that reduce sensititity to irrigation costs. The increased involvement may equally mean that farmers who are commercially benefiting from the gains of irrigation, don't mind commiting more resources because of expected higher returns. Such category of farmers are likely to invest in more pumping hours or regular facility mainenance, leading to slightly higher involvement. This findings is in line with studies in Sub Saharan Africa, showing that irrigation cost affects farmers' participation or water-use decisions (Faye and Von Braun, 2024; Faye and Von Braun, 2025). However, modelling cost of irrigation in the study area as a continuous predictor, provides novel empirical evidence, highlighting that even marginal cost effects can shape farmers' involvment in river basin irrigation schemes.

Non-significant factors: age, extension services, farm size and education did not significantly influence farmer involvement in irrigation agriculture in the catchment of the Anambra-Imo River Basin Development authority. Although these factors should naturally influence or play major roles in shaping farmer involvement in irrigation activities, their non-significant status is a pointer to the fact that other factors may be more central to farmer engagement in the irrigation project than the ones examined in this study, suggesting that engagement in the scheme is shaped less by personal or background characteristics and more by context-specific economic, institutional, and household factors.

Conclusion

A relatively high participation rate was recorded among the sampled farmers in the Anambra Imo River Basin Development Authority irrigation scheme. Major public investments in agricultural water infrastructure such as these are established to enhance productivity of farmers (Oiganji et al., 2025). Therefore, farmer participation is important, and the extent thus far, is quite commendable, although majority are involved in surface irrigation practice. This is not unexpected due to its characteristic low cost of installation and operation (Muchara, 2025), and the fact that there is abundant water availability through the rivers, streams and underground water. Factors such as years of experience in farming, household size, major occupation, farm income, membership of water user association, play a major role in influencing farmer involvement in irrigation agriculture. However, it is startling to note that though being a member of the Water Users Association should be an incentive to involvement in irrigation agriculture, it is rather a disincentive development. This may be due to management and logistic protocols. The findings, however, necessitates a further investigation into the situation. It is recommended that a participatory irrigation scheme, which should be democratically administered by the farmers and the River Basin Management, be adopted. This would enable the farmers to take charge of the daily sourcing and allocation of water, while the River Basin Authority, as a supervisory body, would create the enabling environment and resources, with a member of the water users association serving as an ad-hoc part of its team.

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