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TOWARDS EFFECTIVE WATER MANAGEMENT: PROBING DETERMINANTS OF TAIL-END FARMERS' PARTICIPATION IN IRRIGATION MANAGEMENT IN SRI LANKA

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A B S T R A C T

Participatory Irrigation management (PIM), a co-management phase of Irrigation Management Transfer (IMT), is a form of collective action that ensures effective irrigation water management through farmer participation. Many scholars in Sri Lanka show an optimistic view of the outcome of PIM in irrigation water supply; meanwhile, few scholars reveal that increasing tail-end farmers' participation in PIM is the most significant challenge for achieving PIM policy objectives. However, to a lesser degree, scholars have evaluated determinants affecting farmers' participation in irrigation water management. This study used primary data from 482 tail-end farmers in the Walawe irrigation scheme, Sri Lanka, where PIM is being implemented. The authors contoured a stepwise logistic regression model to determine spatial and non-spatial factors influencing tail-end farmers' participation in collective action. The results of the regression analysis reveal accessibility to extension services, head farmers' time spent on farming, branch canal's distance to plot location, provision of fertilizer subsidies, head farmer occupation status, field canal water dependency, cropping pattern, family-support time, and perception towards water adequacy for agriculture as the best predictive factors affecting tail-end farmers' participation in collective action. Another noteworthy finding is the significant effect of access to extension services and fertilizer subsidy provisions on tail-end farmers' participation in collective action. Authors suggest that the Irrigation Agency officers incentivize farmers by providing awareness, assistance, and focused group training in resource-conserving, modern technology, and dryland farming. Similarly, PIM policy should focus on capacity building of ground-level Irrigation Agency officers to extend their adversary services. The government should extend the capacity of fertilizer subsidy programmes from paddy farmers to other field crop cultivators, as many tail-end farmers are engaged in mixed cropping.

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1. INTRODUCTION

Sri Lanka, an agriculturally-based developing country, adopted Participatory Irrigation Management (PIM) in 1992 as a major national irrigation management policy aimed at reducing government irrigation management costs, improving agricultural productivity, and enhancing the standard of living of farmers in the Dry Zone that occupies more than two-thirds of the country's total land area (Amarasingha et al., 2021; Ranagalage et al., 2020). At the co-management phase, three different management models such as Integrated Management of Agricultural Systems (INMAS), Management of Irrigation Schemes (MANIS), and Mahaweli model, were introduced to manage 376 major and minor irrigation schemes in Sri Lanka, which were initiated under the stewardship of the Irrigation Department and Mahaweli Authority of Sri Lanka (Ministry of Irrigation Sri Lanka, 2022; Paranage, 2020). Under PIM, farmers are incorporated formally as groups to resume management responsibilities concerning a segment of an irrigation system. Farmer Organizations (FOs) are sovereign to act independently concerning irrigation management, and they formulate their own collective action rules, which specify rights and responsibilities among water users (Azemzi and Erraoui, 2021; Takayama et al., 2018). The goal of collective action is to be equitable in water delivery for all irrigated fields in the head-middle-tail reach of each primary, secondary or tertiary irrigation channel of the system to ensure the better performance of irrigated agriculture (Chaudhry, 2018). Although some efforts have been made to provide a reliable water supply to farmers, it has been reported that there exists a lack of compliance and cooperation among farmers to follow collective action rules, which in turn results in poor canal maintenance, inadequate water supply, food insecurity, and poverty at tail-ends (Kumara et al., 2017; Paranage, 2018).

Noteworthy scholars posited that active farmer participation in the irrigation system's planning, operation, and maintenance had warranted sustainable growth in irrigated agriculture. However, scholars worldwide have found many reasons constraining active farmer participation in collective action at tail-ends. For example, water shortage severity, poor irrigation infrastructure, farming experience, education level, insecurity of land tenure, more cultivation expenses, and insufficient knowledge of irrigation technology hampered farmers' participation in collective action (Luo et al. 2018; Adekunale et al., 2015; Sharaunga & Mudhara, 2018) while age, gender, household size, water adequacy, soil quality, fertilizer availability, credit accessibility, framer training and access to extension services enhanced farmers' participation in PIM (Balasubramanya, 2019; Owusu-Sekyere et al., 2021; Sharaunga & Mudhara, 2018). Nonetheless, there is no consensus about what factors revamped farmers' participation at tail-ends.

Scholarly attention has been received in assessing head-tail disparity in irrigation scheme performance, leading to irrigation water supply failure. Although recent meta-reviews of the literature revealed the emergence of head-tail disparity of irrigation systems, key strategies to minimise such a variation have not been adequately addressed in the literature; particularly, studies on factors influencing tail-end farmers' participation in collective action are scanty. Nevertheless, as found in the Sri Lankan context, the evidence of the level of farmers' participation and the factors contributing to tail-end irrigation performance are yet to be abundantly discussed. However, few studies have attempted to discourse the prevailing issues at tail-ends after PIM implementation (Kumara et al., 2017; Paranage, 2018).

Considering the earlier research gap and realising the context of tail-end issues, this study examines the factors affecting tail-end farmers' participation in collective action by considering both spatial and non-spatial factors. Accordingly, the underlying hypothesis is that spatial and non-spatial factors significantly determine tail-end farmers' participation in collective action. The broad implications of this analysis for PIM implementation are focused on reflecting on the prospects to promote tail-end farmers' participation in collective action. The present study's findings are expected to assist policymakers and administrators to ameliorate their strategies and approaches, planners to be more visionary in conceptualising, and principally to develop effective models and methodologies. Therefore, understanding the underpinning factors influencing farmers' participation in collective action is vital for the long-term agricultural sector development of the economy. Moreover, the recommendations of the investigation could prove valuable in terms of contributions to the ongoing efforts by the Irrigation Agencies and the government to enhance PIM's productivity.

The remainder of this academic manuscript is structured subsequently: The subsequent section provides a comprehensive account of the materials and methodologies employed, elucidating the research locale, data collection methods, chosen variables, and the econometric approaches utilized in the analysis. Following this, section three of the paper elucidates and critically discusses the study's findings, leading to the conclusion presented in section four.

2. MATERIALS AND METHODS

2.1 Study location

The study was conducted in the Bata-Atha canal area, the longest tail-end branch canal on the tail-end of the right bank of the Walawe irrigation scheme in Sri Lanka, where PIM has been implemented. The area covers approximately 1737 hectares and is between latitude 6^0 5/ to 6^0 10/ N and longitude 80^0 50/ to 80^0 54/ E (see Figure 1). The area receives a mean annual rainfall of 1,485 mm with an average temperature of 27.8 ^{0}C. Farmers in the irrigated command area cultivate crops during the Maha season (October to February) and Yala season (April to August). Maha is the wet season, wherein the Northeast monsoon materialises, whereas Yala is the dry season, wherein the Southwest monsoon occurs with low rainfall. The area is dominated by reddish-brown earth with a relatively high infiltration rate of approximately 25mm/h (Muthuwatta et al., 2001). The major crops grown in the area include rice, winged beans, snake gourd, brinjal, baby bitter gourd, radish, manioc, finger millet, cowpea, mung bean, and maize. According to the canal irrigation plan of the area, there exist 1573 irrigated plots, and 1407 farmer families live in the two irrigation units: Gotaimbaragama and Kattakaduwa. The area lies under the authority of the

Walawe Residential Project Management Office, Mahaweli Authority of Sri Lanka.

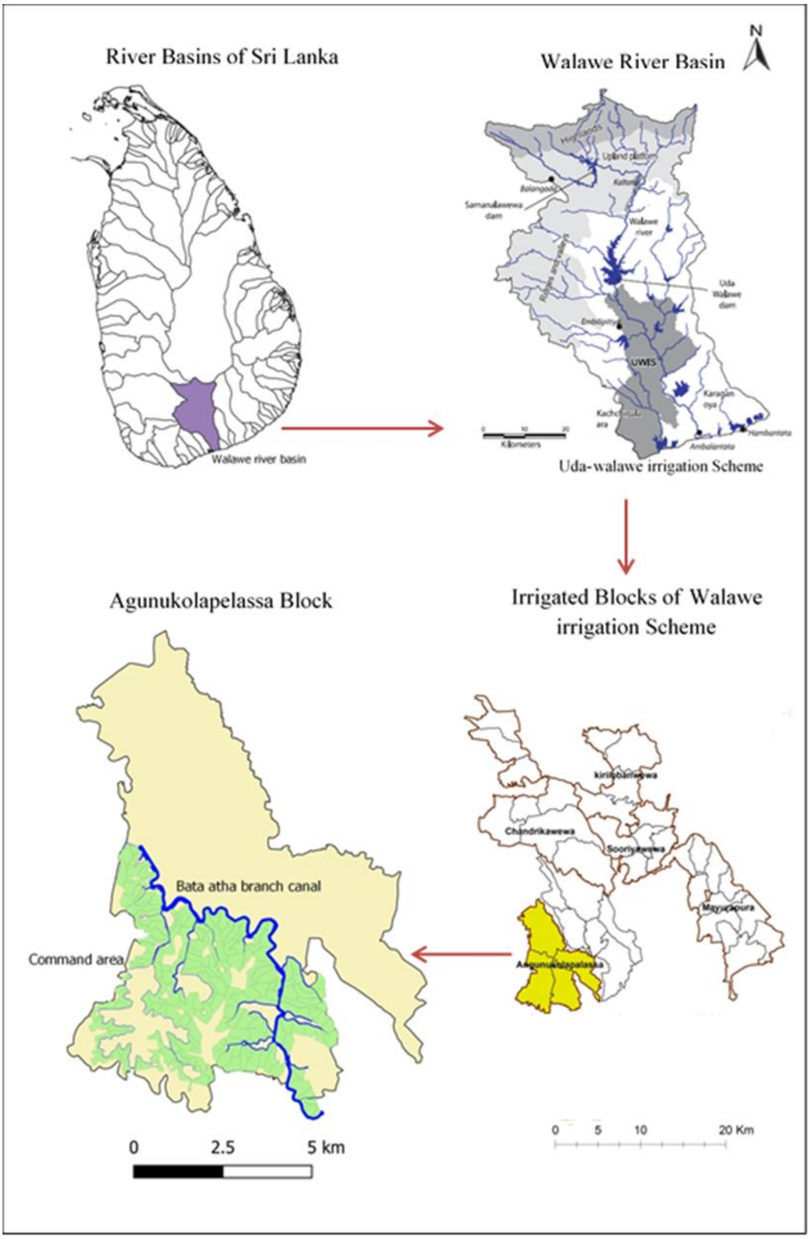


Figure 1. Location map of the study area.

Note. The study area map was prepared using maps of the Land Division of Walawe Residential Project Management Office and Molle et al. (2008).

2.2 Sampling procedure and data collection

A multi-stage sampling procedure was employed to select the area and the respondents. The study area was chosen purposively based on previous literature in the first stage. Aheeyar & Jayasooriya (2015), Buysse (2002), and Senarathne et al. (2021) cited the Walawe irrigation scheme as a traditional water deficit scheme in Sri Lanka and that tail-end farmers in the right bank faced many hardships even under the PIM implementation. In stage two, systematic random sampling was employed to select the irrigated land fields according to the canal irrigation plan of the area. The Yamane formula to size sampling technique was applied to the selected 531 fields in the area as the unit of analysis.

Notwithstanding, 49 selected fields had to be withdrawn due to unforeseen difficulties corresponding with the head farmers during the survey. This resulted in a reduced sample size of 482 fields, as shown in Table 1. Additionally, 225 fields not covered by the sample were selected randomly for external data validation to ensure the consistency of the study results.

Table 1. Number of fields selected for the sample and data validation

Irrigation unit	No. of irrigated fields	Sample size	No. of validation fields
Gotaimbaragama	874	246	109
Kattakaduwa	699	236	116
Total	1573	482	225

Source: Field Survey, 2021

The principal data collection instrument was a structured questionnaire survey administered by 21 FO leaders familiar with the background of concerned farmers. The FO leaders were trained to administer the questionnaire through role-plays. Before the primary survey, a pilot survey was administered concerning 50 randomly selected irrigated fields to assess the reliability and validity of the questionnaire. In addition, where possible, the information provided by the farmers was cross-checked for accuracy through field observations and informal interviews with farmer leaders, neighbouring farmers, and Mahaweli officials. A Focus Group Discussion (FGD) with 14 Mahaweli officers was conducted to scrutinise the area's collective action rules and PIM policy implementation.

2.3 Conceptual and analytical frameworks

Rice is the staple food for Sri Lankans and provides the livelihood of more than 1.8 million farmers (Parasuraman & Weerasinghe, 2021). With the population increase and intense food demand, cultivation areas have been expanded to marginal areas. As a result, irrigation has been treated as an integral part of agriculture in Sri Lanka, where land in the Dry Zone is not productive without providing irrigation water because of seasonal rainfall irregularity and water scarcity (De Silva et al., 2020; Sakalasooriya 2021; Thadshayini et al., 2020). Besides, some studies highlighted the increasing demand for irrigation over the past few decades in the DZ due to the vulnerability of Northeast monsoons and consecutive dry days (De Silva et al., 2020). Himasha et al. (2021) have revealed that paddy production in 2009 declined by 1.5 million metric tons compared to the total production in 2008, mainly due to insufficient water for cultivation during the Yala season; this was attributed to a delay in the onset of monsoon rains and the ensuing uncertainty in the release of water for cultivation. De Silva et al. (2020) showed that the vulnerability of the Dry Zone in Sri Lanka is higher than that of the Wet Zone because the needed amount of rainfall did not come at the right time of the growing season in recent decades. Because the seasonal rainfall variability has increased, it is estimated that approximately 350,000 ha of paddy lands have become vulnerable to drought (Warnakulasooriya & Shantha, 2021).

By 2019/20, Sri Lanka was producing about 4.1 million metric tons of rice per annum, and this was predicted to grow to about 5.3 million tons of rice in 2050 to meet the needs of the rising population (Chowdhury et al., 2017; Galappattige, 2020). Increasing demand for water from the domestic and industrial sectors is bound to have a negative effect on the irrigation water requirement. Then, the irrigation water supply becomes even more critical in the Dry Zone. Therefore, irrigation management has become a prominent issue among Dry Zone farmers, mainly dependent on rice cultivation, which requires plenty of water. In this context, the emerging discourse is how water resources would be managed in the next few decades regarding the agricultural sector and how irrigation efficiency and land productivity should be improved amidst the subsisting compulsion. Thus, the efficient management of irrigation systems has become an accountable and concurrent task concerning Dry Zone farmers, as they are excessively dependent upon irrigation water supply.

At the co-management phase of IMT, the active participation of irrigation agencies and farmer organizations is essential in irrigation water management. Furthermore, the compliance and contribution of farmers at both head-ends and tail-ends are required, which would lead to participation in operation and maintenance (O&M) to achieve the sustainable goals of PIM. However, head-tail disparity in irrigation water supply resulted from the inconsistency of farmers' participation in collective action, leading to increased poverty, food insecurity, and deterioration of irrigation infrastructure at tail-ends. Therefore, time is the key to identifying factors influencing tail-end farmers' participation in collective action.

The study's dependent variable was conceptualised as farmer participation in collective action, which was determined based on the collective action rules formulated by the Irrigation Agency and FOs. Five collective action rules are mandatory for all farmers who have irrigated allotments in the scheme. Such collective action rules are:

(1) Enrol as a FO member: Being a member of an irrigation system is mandatory for all landholders or plot cultivators within the command area. They are required to pay membership fees annually.

(2) Attending Annual General Meeting (AGM): Participation in the AGM to elect farmer representatives and committee members, approve seasonal water schedules, and discuss matters with Mahaweli officers. All members are required to participate in the AGM at the beginning of every cultivation year (mostly in March).

(3) Attending Seasonal General Meetings (SGMs): It is a common platform to discuss and solve matters related to FO finance, canal maintenance and repairs, water supply, and cultivation practices. According to the Agrarian Services Act No. 58 of 1979, holding SGM at least once every four months is required. Accordingly, all FOs have three SGMs per year. According to the FO rule, members are required to attend at least two meetings per year.

(4) Canal cleaning: Every farmer in the scheme is responsible for cleaning and observing the physical condition of a portion of the distributary and field canals. Farmers are asked to clean and de-silt the canals four times per year. However, cleaning at least once at the beginning of each season is required.

(5) Maintenance fee payments: Farmers are required to make a maintenance fee payment to their FO at the beginning of each season. The fee amount is variable and not equal for all FOs. The members of each FO decide the amount at an AGM according to their requirements and willingness to pay.

Since all these five activities were equally weighted by 14 Mahaweli officers and 10 FO leaders in the study area, farmers were asked the actual frequency scores of their attendance for each activity to assess the farmers' participation in collective action. Accordingly, a farmer's score may range between 0 to 11 for five collaborative efforts. Based on each activity's minimum required participation score, a cut-off mark of eight was assigned to determine the active and inactive farmer participation. Accordingly, the respondents who obtained less than eight were marked inactive participants, classified as 0, and those who received greater than or equal to 8 were marked as active participants, classified as 1. In addition, the independent variables were organized into two broad dimensions: spatial and non-spatial.

Further, they were subcategorized as social, economic, institutional, management, locational and physical for a strong interpretation. The selection of 30 factors was based on the literature review, FGD, informal discussions, and the pilot study results. Moreover, to build a regression model, 22 significant explanatory variables out of 30 were selected at a 5% significant level based on Spearman's rho correlation test (see Equation 2). The plot size, family size, off-farm income, access to credits, use of agro-well water, and distance to the nearest market were not significantly associated with tail-end farmers' participation in PIM and were removed from the analysis. Moreover, the head farmer gender and attending farmer training were eliminated from the analysis due to insufficient frequencies of categories.

2.4 The empirical model

Many scholars pointed out several advantages of using logistic regression over other inferential analysis techniques (Kleinbaum & Kelin, 2019; Venter, 2020). Those advantages are high flexibility and easy-to-use functions, easily incorporable numerous independent variables such as a mix of continuous, discrete, and dichotomous variables, relatively free of restrictions, no assumptions about the distributions of the predictor variables, and emphasis on the probability of a particular outcome of each case. While examining the factors influencing the distribution of active and inactive participation of farmers in PIM, it is vital to predict their participation in PIM to expedite the development of PIM in the tail-end area of the irrigation scheme.

Stepwise logistic regression was performed to evaluate the influence of spatial and non-spatial factors on the likelihood that respondents would participate actively in collective action. Some scholars recommend the forced entry method in logistic regression analysis for theory testing, while others suggest the stepwise method for exploratory research (Field, 2005). After attentive consideration of the literature and the study objectives, the stepwise method was selected for the model building. This study incorporated the Forward LR (Likelihood Ratio) method under the stepwise approach. The reason for choosing this method was that the model embodied variables with the most significant score statistics (the cut-off point for significance being .05), which described how well the model fit with observed data (Kleinbaum & Kelin, 2019). Kleinbaum and Kelin (2019) demonstrated that the likelihood ratio is the most reliable method compared to score and Wald statistics. Moreover, no past research could show reliable predictors expected to determine the tail-end farmers' participation in PIM. As such, this study assimilated the Forward LR method to examine tail-end farmers' participation in collective action.

The study employed binary logistic regression to analyse the determinants affecting tail-end farmers' participation in PIM. The dependent variable of the study is coded as a binary choice:

Whether a farmer was actively participating in collective action during the cultivation year 2020/2021

1 = Yes, active and 0 = No, inactive

After checking significance, outliers, and multicollinearity among the independent variables, 22 were selected for the model run. Of these 22 variables, 12 were non-spatial, and 10 were spatial factors. The multivariate logistic regression equation is given by:

$$y = Logit\,(p) = ln\,[P / (1-P)] = \beta 0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_q x_q \quad \ldots(1)$$

Where p is the probability of farmer participation (Y) is 1, p (1-p) is the so-called odds or likelihood ratio, $\beta 0$ is the intercept, and $\beta 1$, $\beta 2$, …, βq are coefficients, which measure the contribution of independent factors x1, x2, …, xq to the variations in Y. To interpret the equation's meaning appropriately, it is necessary to express the coefficients as a power of the natural log (e) that represents the odds ratio. Based on equation 1, the model was specified as:

$$y = Logit\,(p) = ln\,[\,p / (1-p)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14} + \beta_{15} X_{15} + \beta_{16} X_{16} + \beta_{17} X_{17} + \beta_{18} X_{18} +$$

β_{19} X_{19} + β_{20} X_{20} + β_{21} X_{21} + β_{22} X_{22} ... (2)

Where, y represents farmer participation in collective action (dependent variable), X_1 to X_{22} represents head farmer age (years), head farmer education (years), head farmer farming experience (years), head farmer occupation status (dummy), Plot ownership (dummy), cropping pattern (dummy), size of irrigated cultivated area (acres), average irrigated cultivation expenses (LKR/season), average irrigated farm income (LKR/season), average head farmer spend time per unit area (hours/season), average family support time for farming (hours/season), receiving fertilizer subsidy (dummy), extension services contact (dummy), branch canal length in relation to the plot location (meters), total canal length (DF canal length) from distributary outlet to field inlet (meters), head farmer's home location in the plot (dummy), number of plots in the field canal command area (numbers), distance from Unit Manager's (UM) office to irrigated plot (meters), field canal water dependency (dummy), number of canal water received days (days/season), perception about water adequacy for cultivation (dummy) and irrigated canal slope in relation to the plot location (percentage) while β_0 to β_{22} are the parameters to be estimated. Further, Spearman's rank-order correlation results revealed that all these independent variables are significantly associated with tail-end farmers' participation.

3. RESULTS AND DISCUSSION

3.1 Summary statistics of variables and expected effects

The survey disclosed that most of the sampled head farmers actively participated in collective action (59%). The mean age of the farmers was 56, implying that more elderly farmers are engaged in farming than younger ones. This is comparable to the findings of Sharaunga and Mudhara (2018) and Sheikh et al. (2014), implying that older farmers had more experience and time to engage in collective activities. In contrast, Nhundu et al. (2015) found that the younger farmers could work productively, possessing modern technical knowledge. Based on the literature, head farmer age was hypothesized to have a significantly positive or negative effect on farmer participation in collective action. Besides, the average head farmers' time spent on schooling was eight years, indicating that most sampled farmers had attained a secondary level of formal education. Previous studies (Muchara et al. 2014; Nhundu et al. 2015) have shown that head farmer education had a mixed effect on participation decisions. They showed that having a superior educational background allowed them to learn about new irrigation techniques. However, some scholars imparted that educated people engaged in more off-farm employment to support livelihood. Accordingly, authors draw a priori expectation that head farmer education could significantly or negatively affect farmer participation in collective action. The years of farming experience were another significant factor affecting farmer participation. According to the survey, the mean value of farming experience was 38 years, manifesting that most farmers had many years of experience in irrigated farming. Some scholars (Shantha & Ali, 2013) posited that tail-end farmers faced long-term farming challenges. Hence, farming experience was expected to have a significantly negative impact on farmer participation.

Regarding land tenure, 81.7% of the sampled farmers cultivated their parcels of land under the Mahaweli permit. This implies higher tenure security to develop their farming by adopting new technologies such as drip irrigation or sprinkler irrigation techniques. Empirical studies revealed that land insecurity was one factor that negatively affected the long-term investment for cultivation and common pool resource management (Sharaunga & Mudhara, 2018). Consequently, plot ownership was expected to positively affect farmer participation in collective action.

At the initial stage of the resettlement project, every farmer was given 2.5 acres of low land and 0.25 acres of high land for cultivation. However, the sizes of cultivation plots had not been the same for some farmers due to the absence of clear land boundaries and ad hoc land fragmentation from generation to generation. According to Spearman's rho correlation, plot size was not significantly associated with farmer participation, but the size of the irrigated cultivated area was. Moreover, the survey found that 71% of responders could not cultivate their whole irrigated plots due to other reasons like water inadequacy, head farmer occupation status, or building homes in their cultivated fields. Correspondingly, the mean cultivated area was 1.6 acres. Sharaunga & Mudhara (2018) and Sithole et al. (2014) reported that farmers who had large farms actively participated in collective action as crop water requirement was high for them. Based on these findings, the size of the irrigated cultivated area was assumed to have a significantly positive influence on tail-end farmer participation.

Additionally, farmers bear cultivation expenses, including grain, machine, hired labour, fertilizer, pesticides and weedicides costs. Concerning the cost of power, farmers who cultivate paddy use machinery for land preparation (ploughing and levelling), harvesting and drawing, threshing, and winnowing. During the field survey, it was revealed that many farmers worked in harmony and helped each other. It was called "Attama", one of the traditional labour exchange patterns practised in Sri Lanka. The average seasonal irrigated cultivation expense was LKR 50,000. As no research that studied the effect of cultivation expenses on farmer participation could be found, it is plausible to draw a prior expectation that cultivation expenses have a mixed significant impact on farmers' participation.

The mean of seasonal irrigated farming income was LKR 100,000, and the standard deviation was LKR 76.62, indicating the highest variation from the mean. Alam et al. (2012) found that the likelihood of farmer participation was higher when they received a higher return from irrigated farming. Based on these studies, it is predicted that there exists a significantly positive impact of irrigated income on farmer participation in PIM. Additionally, 69.3% of the farmers were engaged in full-time farming, stipulating that the subsistence of most of the farmers in the area revolves around irrigated farming. Miao et al. (2015) established that farmers who depend solely on agriculture were likelier to participate in common-pool resource management. Studies conducted by Nhundu et al. (2015) and Sharaunga & Mudhara (2018) proclaimed that farmers engaged in off-farm were less likely to participate in collective action. Grounded on these findings, it is logical to assume that farmers who engage in full-time farming are more likely to participate in collective action rather than those who aren't. As per the current study, 43.5% of sampled farmers cultivated paddy, while 57.5% practised mixed cropping in which they grew different types of other field crops (OFCs) with or without paddy or permanent crops. With the findings of Sserunkuuma et al. (2003), who reported that paddy farmers were more likely to pay irrigation fees as paddy requires more water to grow, the authors draw a presumption that paddy cultivation will positively affect the probability of farmers' participation in collective action.

Furthermore, this paper established a significant association between head farmers' time spent farming and family support time for farming activities and tail-end farmers' participation. According to the authors, no previous scholar has studied whether these factors significantly influenced farmer participation in collective action. However, Muchara et al. (2014) and Nhundu et al. (2015) revealed that the support of family members has a positive and significant effect on farmer participation. According to the results, the mean value of head farmer time spent per unit area was 95.76 hours, while the mean family support time per season was 32.95 hours. In this study, the authors expect head farmer time spent on farming and family support time to significantly impact the likelihood of farmer participation in collective action.

As per the survey results, 72.4% of the farmers received fertilizer subsidies from the government, implying that farmers' input costs were somewhat lessened. In 1962, the Sri Lankan government initiated a fertilizer subsidy programme for farmers to increase land productivity and achieve national self-sufficiency in rice. This initiative is acknowledged as a life-saving incentive by paddy farmers and some OFCs farmers to participate in collective action. According to the FO rule, farmers who need fertilizer subsidies should get FO membership, maintenance fee payments, and canal cleaning as required, seasonally. Based on this rule, the authors hypothesize that fertilizer subsidy provision will positively influence farmers' participation in irrigation management activities. Most farmers (57.9%) did not contact extension services, while 77.8% did not participate in training programmes for the last ten years. This indicates the lack of institutional linkage between field officers and the tail-end farmers. Etwire et al*.* (2013) and Nhundu et al*.* (2015) posited that extension services contact increased the probability of farmers' participation. Since institutional services are engaged in the capacity building of farmers, access to extension services is expected to significantly affect the likelihood of farmer participation in collective action.

Moreover, previous studies revealed that the canal distance was significantly associated with farmers' participation in collective action regarding spatial factors. A branch canal generally takes water from the main canal and delivers water to the distributary canals. Next, the distributary canals pass on water to all field canals. As branch canal length increases, water will likely decrease due to evaporation, seepage, and illegal water tapping. Muchara et al. (2014) pointed out that water inadequacy lowers farmers' incentive to participate in collective action. Contradictory findings were reported by Sheikh et al. (2014), revealing that tail-end farmers' participation was higher than head-end farmers since they exert much effort into getting canal water. According to the present study, the minimum length of the branch canal to the sampled plot location was 653.65 meters, while the maximum length was 13.64 kilometres. The mean of branch canal length was 6 kilometres, and the mean of sub canal length to the plot location was 2. Based on the previous findings, branch canal length and total canal length from the distributary outlet to the plot inlet were postulated to have significant positive or negative effects on farmers' participation.

Furthermore, due to the increase in the number of plots in the field canal command area, cultivators must be alert regarding water supply time, illegal water tapping, or uneven water sharing. Sometimes, tail-end farmers in large field canal command areas may be reluctant to cultivate their plots due to long-term water inadequacy. According to the survey, the minimum number of plots in the field canal command area was three, the maximum number of plots in the command area was 24, whereas the mean field canal plot load was 11. Since no literature that studied the effect of field canal load could be found, the authors hypothesize that it has mixed results on tail-end farmers' participation in collective action. Conforming to the study, every irrigation unit has a Unit Manager (UM) and a field officer responsible for assisting farmers in solving land issues, cultivation issues, and FO matters. Matters related to land permission, cultivation matters, FO collective activities, canal water distribution, and water disputes should be informed to the UM office in the area. If the UM cannot solve any of these matters, they are responsible for escalating them to the Block Manager. Moreover, UM and field officers in each unit are required to visit the irrigated plots within their area of authority. Based on informal discussions with farmers, authors draw a presumption that a longer distance to the UM office from the plot location will negatively affect farmer participation in collective action.

There were no facilities to assess the water quantity received by each plot during a season. A specific fixed amount of water is given a season for each distributary canal in total irrigated lands in each field canal command area. The rotational water issue starts at the land preparation stage, and each plot cultivator knows on which day they can extract water from the field canal outlet, considering a week. During the field observation, it was noticed that some tail-end farmers did not receive their due amount of water against some crop growth stages. To understand the situation better, this study collected the total number of canal water received days during the season for each sampled plot. Accordingly, the minimum number of canal water received days per season was 1, the maximum was 22.5 days, and the mean canal water received days was 19. This study expects that the number of canal water received days per season will positively affect the possibility of farmers' participation. Walawe irrigation scheme is one of the resettlement projects in Sri Lanka where settlement areas and cultivated plots were allocated separately for the 1st generation at the initial settlement project period. During the survey, it was witnessed that 2nd and 3rd generation farmers had moved to their cultivated plots to settle as land as a resource is scarce in supply. The study found that 35% of the farmers lived in cultivated fields while 65% lived in the settlement areas near their plots' locations. Sheikh et al. (2014) and Sithole et al. (2014)

discovered that distance from home to farms negatively affected farmers' participation in collective action. This led the authors to assume that farmers who settle in irrigated plots are more likely to participate in collective action. The study also found five ways to draw water to the plot location. They are (1) water from the field canal, (2) water from the drainage canal, (3) water from both the field canal and drainage canal, (4) water from the village tank, and (5) water from both village tank and field canal. According to the survey, 69.7% of the farmers could access only field canal water, while 30.3% could access alternative water sources except for field canals. No scholar has studied the effect of these types of water acquisition methods on farmers' participation in collective action. Therefore, it was hypothesized that field canal water dependency would have a mixed effect on farmer participation.

Despite that, authors presuppose that the canal slope against the plot location will positively affect farmers' participation decisions because an increase in canal gradient results in superior water flow. Moreover, the perception of water abundance is critical as it determines the farmers' decision to cultivate their plots. Besides, the perception of water adequacy depends on crop type, soil type, water quantity, and type of water acquisition. As per the survey results, many total respondents (61.2%) perceived water as inadequate for their cultivation. Muchara et al. (2014) postulated that farmers who faced water shortages in the long run were reluctant to participate in irrigation management activities. As such, this paper assumes that farmers who perceive water as adequate for their farming are more likely to participate in collective action.

Table 2. Descriptive results of variables and expected effects on tail-end farmers' participation in collective action

Variable (continuous)	Description	Mean	SD	Expected sign
Non-spatial factors				
Social factors				
Age	Head farmer age in years	55.66	11.90	**+/-**
Education	Head farmer education in years	8.12	3.42	**+/-**
Farming experience	Irrigated farming experience of the head farmer in years	37.69	13.23	**-**
Plot ownership	1 if the farmer owns the plot under cultivation; 0 if otherwise	0.82	0.39	+
Economic factors				
Size of cultivated area	Size of irrigated cultivated area (Acres)	1.62	0.84	+
Cultivation expenses	Average cultivation expense per season (in thousand LKR)	50.13	34.76	+/-

Irrigated income	Average irrigated income per season (in thousand LKR)	100.56	76.62	+
Occupation status	1, if the farmer engages in full-time farming; 0 if part-time farming	0.69	0.46	+
Cropping pattern	1, if the farmer practices in paddy farming only; 0 if mixed cropping	0.44	0.50	+
Management factors				
Head farmer spending time	Average head farmer spending time per unit area per season (hours)	96.88	61.52	+
Family support time	Average head farmers' family support time per season (hours)	32.95	43.14	+
Institutional factors				
Fertilizer subsidy	1, if the farmer got fertilizer subsidy; 0 otherwise	0.72	0.48	+
Extension services contacts	1, if the farmer contacts extension services; 0 otherwise	0.42	0.50	+
Spatial factors				
Locational factors				
Branch canal length	Branch canal length to the plot's location (Kilometres)	6.47	3.87	**+/-**
DF canal length	Canal length from distributary water outlet to plot's inlet (Kilometres)	2.44	2.92	**+/-**
Field canal load	Number of plots in the field canal command area	10.81	4.02	+/-
Distance to UM office	Distance from plot's location to UM office (Kilometres)	2.64	1.25	-
Water received days	Number of canal water received days per season	19.23	5.04	+
Home location	1, if the farmer's home is located in the cultivated plot; 0 if otherwise	0.35	0.48	+
FC dependency	1, if a farmer can access only a field canal water, 0 if otherwise	0.70	0.46	+/-
Physical factors				
Canal slope	Average canal slope to the plot's location (Percentage)	0.29	0.18	+
Water adequacy	1, if the farmer perceives about water adequacy for farming; 0 if otherwise	0.35	0.48	+

Source: Field Survey, 2021
Note. SD is an abbreviation for standard deviation.

3.2 *Comparison between active and inactive participants' characteristics*

Farmer participation was categorized into two: active and inactive. Table 3 shows the characteristics of active and inactive participants in the Bata-Atha branch canal command area. The mean age of active participants was significantly lower than that of inactive participants. Many active participants were aged between 37-54 years, while many inactive participants were aged 55-74 years. It was observed that active farmers' mean years of farming experience were significantly lower than that of inactive farmers. The variation in farming experience was significant at a 5% level. Sserunkuuma et al. (2003) found that the virtue of the experience determines farmers' participation in collective action. The study findings reflect that older farmers with greater tail-end farming experience are less likely to participate in collective action. Most active and inactive farmers were literate in the study area. However, the mean education level of active participants was significantly higher than that of inactive participants, implying that farmers can adopt new irrigation techniques and apply improved farming practices. Besides, the mean cultivated area size between the active and inactive participants differed significantly at a 1% level. The mean cultivated area of active farmers was higher than that of inactive farmers, revealing that the higher the irrigated cultivated area, the higher the crop water demand would be, resulting in a higher probability of farmer participation in irrigation water management.

Table 3. Comparison between active and inactive participants' characteristics: Continuous variable

Variable	Mean		Independent-sampled T-test (t)
	Active farmers	Inactive farmers	
Age	54.29	57.62	-3.05 ***
Farming experience	36.64	39.20	-2.09 **
Education	8.51	7.56	3.04 ***
Size of cultivated area	1.87	1.19	8.40 ***
Cultivation expenses	58.62	38.31	6.63 ***
Irrigated income	117.33	76.52	5.96 ***
Head farmer spending time	119.79	64.01	10.93 ***
Family support time	38.05	25.65	3.07 ***
Branch canal length	6.15	6.92	-2.16 **
DF canal length	1.91	3.20	-4.89 ***
Field canal plot load	10.10	11.82	-4.73 ***
Distance to UM office	2.46	2.90	-3.67 ***
Water received days	20.42	17.51	6.49 ***
Canal slope	0.85	0.83	2.69 ***

Source: Field Survey, 2021
Note. Significance at .05, .01** and .001 level ****

Regarding cultivation expenses and irrigated income, most active participants expended more money for their cultivation and earned more income than inactive participants. Similarly, active farmers spent more time farming than inactive farmers, where the mean of active farmers' time spent farming per unit area was 120 hours per season, reporting that active farmers spent more time farming than inactive farmers. Concerning family support, active farmers had more assistance from their family members compared to inactive farmers. The average family support time for active farmers was 38 hours, while the difference in family support time was significant at a 1% level. In addition, the mean branch canal length and DF canal length to the plot location were higher for inactive participants, establishing that many farmers are inactive at the tail-end of branch canal and distributary canals. Generally, UMs and field officers closely associate with farmers to solve problems in the irrigation scheme. The study reflected that the mean distance to the UM office from the plot location was higher for inactive participants than for active participants. In addition, the mean of field canal load for active participants was ten plots, while the same for inactive participants was 12 plots. Accordingly, the mean field canal load was higher for inactive than active participants. Besides, the mean canal slope and canal water receipt days were higher for active participants, reporting that farmers are more involved in the area where adequate water for farming is available.

Regarding plot owners, 61.7 % of them actively participated in collective action (See Table 4). Accordingly, the percentage of active plot owners was higher than that of inactive land occupiers (53.4%). Active participation of full-time farmers in irrigation water management was 71.9%, whereas the inactive participation for part-time farmers was 70.3%, similar to plot owners. Additionally, 76.2% of active participants were paddy cultivators who received fertilizer subsidies from the government. Crop diversification programmes were initiated at the tail-end blocks to lessen the risk of crop losses due to seasonal water shortages. However, the provision of fertilizer subsidies is one of the more significant incentives for tail-end farmers to cultivate paddy crops, the staple food among Sri Lankans. Contrarily, 82.7% of inactive farmers who were not eligible to receive fertilizer subsidies occasionally attended collective action, especially for SGMs. A large group of active farmers (83.3%) had access to extension services, and 70.8% of the active farmers were living in settlement areas in the scheme. The Mahaweli irrigation system adopted a pattern of cluster settlements that developed physical, economic, and social linkages among settlers. Many farmers in the irrigation scheme settled in allocated settlement areas near their cultivated fields, while few settlers from the 2nd generation settled in their irrigated fields due to landlessness.This paper revealed that farmers in settlement areas are more likely to attend collective action than those in irrigated fields.

Regarding water sources, 81.3% of the active farmers in tail-end areas depended exclusively on field canal water. In contrast, some farmers can access drainage canals and village tanks to extract water depending on their plots' locations. Farmers who conjunctively use field canal water and alternative water sources are less likely to contribute to collective action. Moreover, 51.4% of farmers participating actively in PIM perceived that available water was sufficient for their cultivation. In comparison, 79.3% of inactive participants perceived that water was insufficient for farming.

Table 4. Comparison between active and inactive participants' characteristics: Dummy variables

Variable		Percentage (%)		Chi-square test (x^2)
		Active farmers	Inactive farmers	
Plot ownership	1 Owner	61.7	38.3	6.15 **
	0 Not owner	46.6	53.4	
Occupation status	1 Full-time	71.9	28.1	73.46 ***
	0 Part-time	29.7	70.3	
Cropping pattern	1 Paddy	76.2	23.8	44.60 ***
	0 Mixed crops	45.6	54.4	
Fertilizer subsidy	1 Yes	74.8	25.2	129.14***
	0 No	17.3	82.7	
Extension services contact	1 Yes	83.3	16.7	84.04***
	0 No	41.2	58.8	
Home location	1 In irrigated plot	29.2	43.9	10.43 ***
	0 In the settlement area	70.8	56.1	
FC water dependency	1 Field canal only	81.3	53.0	42.94 ***
	0 Alternative sources	18.7	47.0	
Water adequacy	1 Adequate	51.4	20.7	45.03 ***
	0 Not Adequate	48.6	79.3	

Source: Field Survey, 2021
Note. Significance at .05, .01** and .001 level ****

3.3 Factors affecting farmers' participation in collective action

The binary logistic regression model was statistically significant, x^2 (9) = 358.425, P <.0001. The model explained 71% (Nagelkerke R^2) of the variance in farmer participation and correctly classified 86.9% of cases. When comparing the log-likelihood static of the new model with the baseline model, it has dropped from 652.77 to 294.342, indicating that it best fits the new model than the baseline model. The chi-square value for Hosmer and Lemeshow test was non-significant, x^2 (8) = 3.586, p = .892, indicating the data fit the model competently. Moreover, the model correctly classified 159 farmers who did not participate in collective action but misclassified 39 others. Accordingly, 83.3% of farmers were predicted by the model as inactive participants. Likewise, the model correctly classified 260 farmers actively participating in collective action and misclassified 24 cases. Hence, the model accurately predicted 91.5% of the farmers as active participants in collective action. Accordingly, the whole step of model validity established that the model was valid in every aspect. Table 5 reflects the binary logistic regression results on factors affecting farmer participation in collective action at the tail-end area.

Table 5. Stepwise binary logistic regression results on selected factors affecting farmer participation

Variable	**Coef.**	**Std. Err.**	**Wald**	**df**	**Sig.**	**Exp(B)**	**VIF**
Extension contacts	2.680***	0.380	49.813	1	.000	14.582	1.283
Head farmer spending time	1.803***	0.260	47.897	1	.000	6.066	1.264
Branch canal length to the plot location	-0.925***	0.177	27.173	1	.000	0.396	1.188
Fertilizer subsidy	2.178***	0.457	22.677	1	.000	8.827	1.901
Occupation status	1.293***	0.369	12.262	1	.000	3.645	1.308
FC water dependency	0.947**	0.349	7.371	1	.007	2.578	1.263
Cropping pattern	0.928**	0.354	6.871	1	.009	2.530	1.503
Family support time	0.367**	0.163	5.065	1	.024	1.444	1.270
Perception towards water adequacy	0.631*	0.313	4.061	1	.044	1.879	1.154
Constant	-4.594	0.614	56.059	1	.000	0.010	
Number of observations	482						

Source: Field Survey, 2021

Note. R^2 = .892 (Hosmer and Lemeshow), .525 (Cox & Snell), .707 (Nagelkerke). Model = x^2 (9) = 358.425 (P< 0.001), correlation is significant at the .05, .01** and .001 level ****

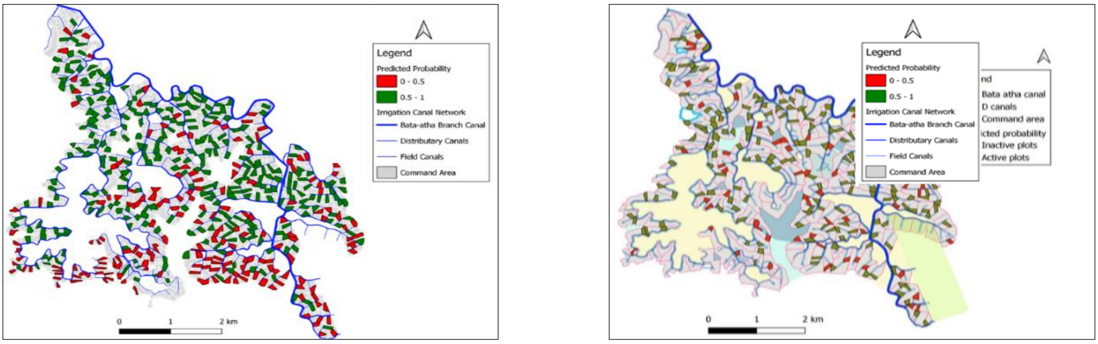
According to the model result, the six non-spatial factors: (1) extension services contact, (2) head farmer spending time for farming, (3) fertilizer subsidy availability, (4) head farmer occupation status, (5) cropping pattern, and (6) family-support time, and three spatial factors: (1) branch canal length to the plot's location, (2) field canal water dependency, and (3) perception towards water adequacy for cultivation were the precise predictive variables that described tail-end farmers' participation in collective action. At least one significant variable represents economic, management, institutional, locational, and physical factors.

The strongest predictor of farmer participation was the extension services contact (β-coefficient = 2.680 and Wald = 49.813), recording an odds ratio of 14.582. Accordingly, the model indicates that farmers who contact extension services were 14 times or more likely to participate in collective action than those who did not. This finding is consistent with Etwire et al. (2013) and Nhundu et al. (2015), who found a significant positive influence on farmers' participation in collective irrigation management. Moreover, the head farmers' time spent on irrigated farming significantly impacted farmers' participation. A one-hour increase in head farmers' time spent on agriculture increased farmer participation in collective action by a factor of 1.803, implying that farmers who spent more time farming were nearly six times more likely to participate than those who spent less time in agriculture. Despite this finding, the branch canal length to the plot location had a negative effect on farmers' participation, indicating that an increase in branch canal length is most likely to result in a lower probability of farmer participation (β-coefficient = -.925, Wald = 27.173, odds ratio = .396). This corroborates the findings of Arun et al. (2012) but contradicts those of Sserunkuuma et al. (2003), who found a significant positive influence of canal distance on farmers' participation in collective action.

Additionally, the provision of fertilizer subsidies significantly positively affected farmer participation. The study found that the likelihood of farmer participation increased by a factor of 2.178 when farmers received fertilizer subsidies. It was more than eight times higher for a farmer who received a fertilizer subsidy than for those who did not. Similarly, Miao et al. (2015) reported a significant positive influence of grain subsidies on farmers' participation in collective irrigation management. Besides, the head farmer occupation significantly and positively affected farmer participation, revealing that a full-time farmer was more than three times higher in participation in collective action than those who engage in part-time farming. Another significant positive factor is field canal water dependency. Farmers dependent solely on field canal water were approximately three times more likely to participate in collective action. Furthermore, cropping patterns significantly influenced the probability of farmers' participation, indicating that paddy cultivators are nearly two times more likely to participate in collective action than those who practised mixed cropping. The findings are aligned with the results of Miao et al. (2015), who reported a significant positive influence of cropping patterns on farmers' participation in collective action.

Family-support time for farming positively contributed to farmer participation in PIM, implying that family-support time increased farmer participation by a factor of 0.367, establishing consistency with the findings of Nakano & Otsuka (2011) and Nhundu et al. (2015), who reported a significant positive effect of family labour on farmers' participation in irrigation water management, implying that head farmers have a greater deal of time to engage in collective action when family members support farming activities. Additionally, farmers who perceived irrigated water adequacy for their farming were approximately two times more likely to participate in collective action than those who perceived otherwise, holding other factors constant in the model. According to the study by Muchara et al. (2014), the perception of water adequacy significantly affected farmers' participation. Conversely, Sharaunga & Mudhara (2018) posited that water shortage severity significantly affected the intensity of farmers' participation in collective action.

The external validation process is required to assign the constant value and coefficient values of the overall model. Accordingly, the accuracy of external model validation is 85.8%, establishing that the constant and coefficient values of the overall model are compatible with the validation dataset. Moreover, it is verified that there is no uncertainty in applying overall model data for future PIM development activities in the area. Figure 2 shows the spatial distribution of active and inactive participants according to the predicted probability values of the overall model. Active participants are shown in green colour, whereas inactive participants are shown in red.



(A) (B)

Figure 2. The spatial distributions of predicted probability values of the logistic model (A) and model validation (B). Data Source: Field Survey, 2021

3.4 Significance of the best predictive factors to enhance tail-end farmers' participation in irrigation management

Although increasing farmer participation at the tail-end of an irrigation scheme is a big challenge with a water deficit, especially in dry periods, the PIM policy implementation aims to enhance farmer participation in irrigation management by empowering the responsibilities of farmers. In this context, the role of the Irrigation Agency is to support farmers in building their capacity while jointly managing irrigation infrastructure. This study found that extension services contact to solve agricultural-related issues is the most influential factor in enhancing tail-end farmers' participation. Moreover, it is also found that head farmers spend time farming, joining fertilizer subsidy programs, head farmer occupation status, field canal water dependency, cropping pattern, family-supportive time, and the perception towards water adequacy for cultivation head farmer spends time for farming are the most influential determinants to increase tail-end farmers' participation in PIM. In addition, an increase in branch canal length is the crucial factor that caused a decrease in the probability of tail-end farmers' participation in collective action.

Based on these key findings, the PIM policy implication should concern the capacity building of UMs and field officers to extend their adversary services for farmers to solve their cultivation matters. At the same time, it is also required for capacity building of farmers by encouraging them to irrigate farming. Field officers can play a vital role by increasing their frequency of contact with particular emphasis on marginalized farmers at extreme tail-ends of the branch canal. Moreover, farmer-to-farmer knowledge transfer methods and social learning methods can be employed to disseminate practical knowledge of farming through FOs. In this regard, UMs and field officers should actively join with FO leaders to organize seasonal meetings productively. In addition, organising focused group training regarding effective resource-conserving, modern technology, and dryland farming through UM offices is vital to increase tail-end farmer participation. The study shows a negative relationship between the branch canal length and farmer participation. Therefore, when farmers are selected for training, it is necessary to prioritize the tail-end of the branch canal area.

Furthermore, providing fertilizer subsidy at favourable prizes for OFC cultivation, like paddy cultivation, is vital to increase farmer participation. Likewise, providing locally improved variety seeds subsidy for Paddy and OFC cultivators through FOs supervision incentivises all farmers to participate in PIM. This is also one of the strategies to increase FOs capacity. The study area has great potential to implement that with Bata-atha agro-technology farm and Mahaweli agro-farms. Therefore, PIM policy should aim to build and strengthen the coordination mechanism between Irrigation Agency and agro-technology farms to conduct training, development programs, and workshops for tail-end farmers.

4. CONCLUSION

Extension services contact to solve agricultural-related issues was the most influential factor affecting tail-end farmers' participation in collective action. Moreover, the findings reveal that head farmers' time spent on farming, provision of fertilizer subsidies, head farmer occupation status, field canal water dependency, cropping pattern, family-support time, and perception towards water adequacy for agriculture had a positive impact on the plausibility of farmers' participation in PIM. Conversely, branch canal length to plot location was the most significant spatial factor that negatively affected the probability of farmers' participation in PIM. The study further revealed that extension services contact strongly influenced tail-end farmers' participation. In the context of PIM development in tail-end irrigated areas, the key strategy to increase farmer participation in collective action might be to improve extension services to solve farmer-faced agricultural-related matters in the area. Therefore, the study proposes that the Irrigation Agency officers incentivize inactive participants by propagating awareness programmes, providing assistance, and focused group training on resource-conserving, modern technology, and dryland farming.

Similarly, PIM policy should also focus on capacity building of ground-level Irrigation Agency officers parallel to the tail-end irrigated farmers to extend their advisory services. Like extension services, the provision of fertilizer subsidies positively affected the likelihood of farmers' participation in collective action. It is therefore suggested that the government should extend the capacity of fertilizer subsidy programmes that target not only paddy farmers but also OFC cultivators, as many tail-end farmers are engaged in mixed cropping. In conclusion, it is better to design and strengthen the decision-making environment of the institutional system under the PIM policy improvement, which should propel beyond the policy formulation of agricultural development.

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