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DETERMINANTS AND MEASURES TO ASSESS FARMERS' PARTICIPATION IN PARTICIPATORY IRRIGATION MANAGEMENT (PIM) AT THE TAIL-END OF IRRIGATION SCHEMES IN SRI LANKA: A REVIEW OF THE EMPIRICAL EVIDENCE

LGDS Yapa, Anisah Lee Abdullah, Ruslan Rainis & GPTS Hemakumara

ABSTRACT

Assessing the determinants affecting farmers' participation in Participatory Irrigation Management (PIM) at the farm household level is vital in identifying the root causes of the prevailing problems at the tail-end of irrigation schemes in Sri Lanka, with a view to finding national level remedies to solve the head-tail disparities in sharing water. The main objective of this study is to propose appropriate determinants and measures to assess farming practices in PIM in Sri Lanka while reviewing the spatial and non-spatial factors that affect, whether significantly or otherwise, farmers' participation in collective activities. A systematic literature review was conducted using PRISMA guidelines. A total of 28 full-text research articles on farmers' participation in collective action were identified to propose determinants and measures to assess farmers' participation in PIM. This study identified significant social, economic, managerial, institutional, locational, and physical factors based on previous studies. Addressing the knowledge gap, this study suggests 36 determinants that are helpful to assess the level of farmers' participation in PIM in Sri Lanka. These include 10 social factors, 6 economic factors, 4 management factors, and 7 institutional factors under the non-spatial category, while 5 of the locational and 4 of the physical factors fall under the spatial category. Moreover, this study ensures consistency between the different measures applied to assess farmers' participation and recommends the usage of distributional and proportional measures to determine farmers' participation in PIM in Sri Lanka as well as in other countries where IMT or PIM is being implemented.

Keywords: collective action, conceptual framework, farmer participation, Participatory Irrigation Management, Sri Lanka

INTRODUCTION

Since the 19th century, Irrigation Management Transfer (IMT), a type of irrigation reform, has been practised widely in more than 57 countries to rectify poor irrigation system performance in government-managed irrigation systems (Garces-Restrepo, Muñoz, & Vermillion 2007). Under the concept of decentralized management and community governance of infrastructure, Participatory Irrigation Management (PIM) is a form of IMT (co-management phase of IMT) in which responsibilities are shared between public sector agencies and farmer organizations (Garces-Restrepo, Muñoz, & Vermillion 2007). According to Alam, Kobayashi, Matsumura, Eshan, Faridullah, and Siddighi (2012), PIM refers to "the involvement of stakeholders in planning, designing, constructing, supervising, policy and

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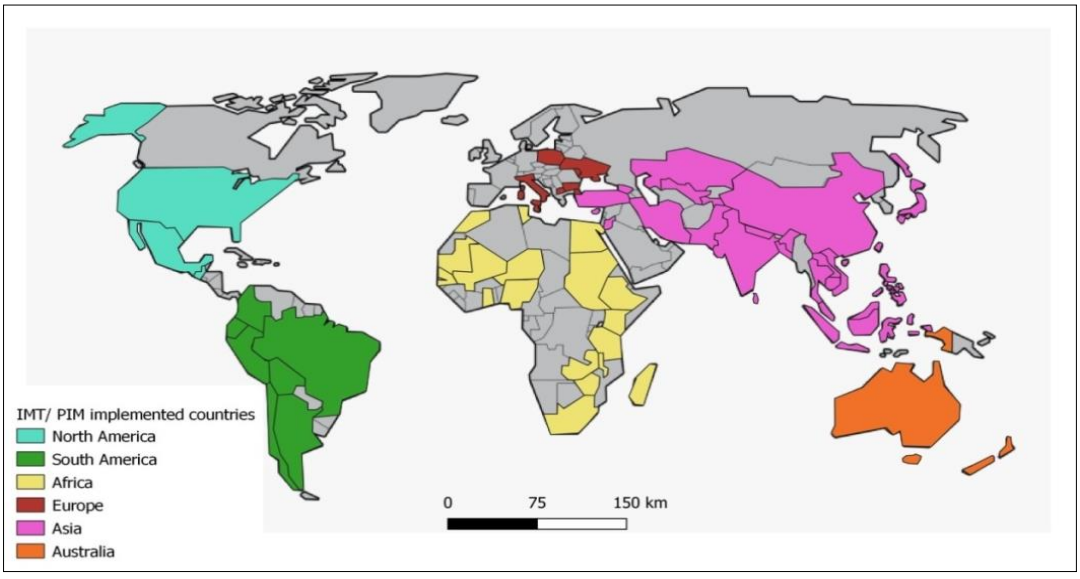
decision making, operating and maintenance and evaluating irrigation systems" (p. 276). Accordingly, farmers are the key stakeholders in PIM because they participate in decision-making at all levels of the irrigation management activities according to their customary rules and cultural norms (Braimah, King, & Sulemana 2014).

In the late 1980s, the Sri Lankan government formally agreed in principle on PIM in a cabinet paper and then approved it as a national policy in 1992 (Aheeyar, Padmajani, & Bandara 2012; Jinapala, Premadasa, Somaratne, Samad, & Lanka 2010). The PIM policy aims to improve the irrigation performance and relieve the government of expenditure on operating and maintenance (O&M) of the irrigation systems through active farmers' participation in the management process by sharing responsibilities with irrigation agency officers (Aheeyar, Padmajani, & Bandara 2012; Groenfeldt 1988). Accordingly, the most significant direct benefits of farmers' participation in irrigation management are improved efficiency and effective O&M, which result in equity, reliability, and timeliness of water distribution, water-saving, and sustainability in irrigated agriculture (Aheeyar 2006; Choukr-Allah 2004). However, more empirical evidence is available in the Sri Lankan literature on the inequity of compliance and contribution of farmers to manage the secondary and tertiary level of irrigation systems (Abhayaratna 1994; Aheeyar, Padmajani, & Bandara 2012). Thus, it is crucial to identify the level of farmers' participation in irrigation management and examine the factors influencing their participation as the long-term sustainability of irrigation schemes is determined by those (Alam, Kobayashi, Matsumura, Eshan, Faridullah, & Siddighi 2012; Muchara, Ortmann, Wale, & Mudhara 2014).

Figure 1: Continents and their countries in the world with IMT implementation



Note. Figure 1 shows the continents and the countries where IMT or PIM is being implemented. This map was created by authors. Adapted from "Irrigation Management Transfer: Worldwide Efforts and Results," by C. Garces-Restrepo, D. Vermillion, and G. Muñoz, 2007, *FAO Water Reports* (No. 32), p. 9, and "Re-visiting What We Know about Irrigation Management Transfer: A Review of the Evidence," by N. Senanayake, A. Mukherji, and M. Giordano, 2015, *Agricultural Water Management 149* (2015), p.178.

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Petty (1995) defines seven types of participation ranging from manipulative participation to self-mobilization that are useful for understanding the different levels of farmers' participation in agricultural development programs and projects where IMT/PIM is implemented. Farmers are required to participate in collective action and perform their assigned roles. Farmer Organizations (FOs) are autonomous in devising their rules to promote water users' collective participation in irrigation management: for instance, holding internal meetings; collecting seasonal water charges or maintenance fees; coordinating water delivery systems; maintaining the secondary and tertiary canals; resolving disputes within the community; and electing farmer representatives (Bastakoti & Shivakoti 2012; Nagrah, Chaudhry, & Giordano 2016). Moreover, Arun, Raj, Kumar, and Kumar (2012) and Muchara, Ortmann, Wale, and Mudhara (2014) categorize collective action into five broad categories: labour-based activities, financial-based activities, supportive-based decision-making, regulation and control, and information dissemination in order to distinguish between different PIM activities for the better assessments of farmers' participation.

In the context of irrigation performance at the tail-end areas, IMT/PIM projects in Mexico, Turkey, China, Vietnam had been reported as success stories (Akhtar & Bhatti 2006; Tanaka & Sato 2003), while many similar projects have failed to achieve effective performance in most Asian countries like India, Pakistan, and Bangladesh (Akhtar & Bhatti 2006; Hamada & Samad 2011; Hussain 2006). Likewise, several Sri Lankan scholars have reported some benefits and drawbacks of PIM, focusing on head-end and tail-end areas (Aheeyar 2012; Jinapala, Premadasa, Somaratne, Samad, & Lanka 2010; Shantha 2017; Shantha & Ali 2011; Yapa, Rainis, Abdullah, & Hemakumara 2020). Many FOs in Sri Lanka successfully manage the tertiary canal system (Aheeyar, Padmajani, & Bandara 2012; Aheeyar & Smith 1999; Esham & Usami 2007), while many others exhibit a high degree of informality with regard to the utilization and mobilization of resources (Aheeyar, Padmajani, & Bandara 2012; Thiruchelvam 2010). Furthermore, Aheeyar and Smith (1999) revealed that the tail-end of the Rajanganaya scheme showed effective performance in the canal water supply. However, the tail-end of Mee-Oya, Mahaweli system B, Nachchaduwa and Hakwatuna Oya scheme showed relatively poor water distribution performance under participatory management (Aheeyar & Smith 1999; Samad & Vermillion 1999; Shantha & Ali 2011). The lack of farmers' compliance in managing irrigation systems and their dissatisfaction restrict the effectiveness of FOs and the performance of the whole scheme in terms of crop productivity, the efficiency of irrigation, and sustainability (Swain & Das 2008; Yapa, Rainis, Abdullah, & Hemakumara 2020). Moreover, the unequal water distribution and inconsistent farmers' participation at the tail-end cause an increasing socio-economic gap between the head-enders and tail-enders in terms of income inequality, poverty, food insecurity, and inefficiency in irrigation (Shantha 2017; Shantha & Ali 2011).

Although the literature on the PIM is rather extensive, to the authors' knowledge, no one has assessed specific factors affecting tail-end farmers' participation in PIM in Sri Lanka. However, the above discussion shows that it is critical to examine the factors that are significantly associated with tail-end farmers' participation, with the aim to improve the overall performance and sustainability of the irrigation systems. Moreover, it is vital to propose determinants and measures to assess the specific factors influencing farmers' participation in PIM. Accordingly, the aims of this paper are (i) to identify specific factors at the household level by reviewing the results of previous studies, (ii) to identify the

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knowledge gap, and (iii) to propose determinants and measures to assess tail-end farmers' participation in PIM in Sri Lanka.

The structure of the rest of this paper is threefold. First, this review describes the social, economic, managerial, institutional, locational, and physical factors found in the previous studies, reporting whether a significant positive or negative effect on farmers' participation has been identified. The significance of each factor is measured at the 90% ($p < 0.10$) level. Secondly, it continues with a comparative analysis of the different measures following a summary of methods applied to measure the level of farmers' participation in PIM and reports whether it is appropriate or not appropriate to assess the factors affecting farmers' participation in PIM. Finally, by identifying the knowledge gap, this paper proposes appropriate measures and determinants to assess farmers' participation in PIM at the tail-end of irrigation schemes in Sri Lanka.

MATERIALS AND METHODS

A systematic literature review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. As shown in Figure 2, four (4) phases, namely, Included, Eligibility, Screening, and Identification, were followed to select relevant literature for the review. All available research articles, conference papers, and research reports were gathered via Elsevier, Google Scholar, and International Water Management Institute (IWMI) database using keywords such as "farmer participation" AND "irrigation management" OR "Participatory Irrigation Management." The following criteria were used to select the literature for this review:(i) Literature must be in the English language, (ii) Studies to be limited in geographic scope to the countries where IMT or PIM is practised, (iii) Publication period of literature to be from 1992 to 2020, and (iv) Studies based on factor analysis to be included in this review. Additionally, all available research papers and conference papers with reference to PIM in the Google Scholar search engine were referred to gather supplementary information for the study.

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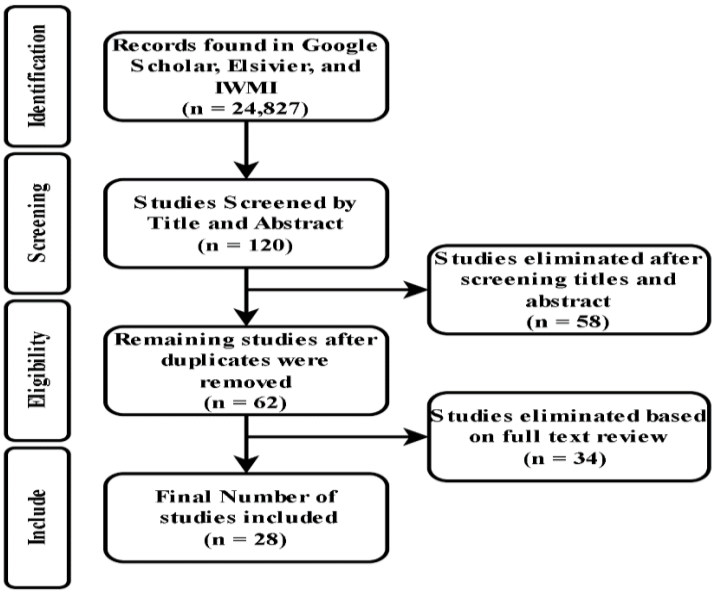
Figure 2: PRISMA flow diagram showing the different phases of study selection



Note. Figure 2 illustrates the literature searching and selection procedure with the number of articles at each stage according to the PRISMA criteria. Adapted from "Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement" by Moher, D., Liberati, A., Tetzlaff, J., and Altman, D.G., *PLoS Medicine*, *6*(7). Copyright 2009 by Moher et al.

RESULTS AND DISCUSSION

Factors Influencing Farmers' Participation in Collective Action

Many scholars have found various individual factors at the farmer household level and reported whether those factors have significantly influenced farmers' participation or decision to participate in collective action (Arun, Raj, Kumar, & Kumar 2012; Muchara, Ortmann, Wale, & Mudhara 2014; Sithole, Lagat, & Masuku 2014). All recognized factors in the existing literature are categorized as social, economic, managerial, institutional, locational, and physical factors, which are discussed in detail in the following sub-sections.

Social Factors

The review establishes that 10 social factors potentially influence farmers' participation in PIM (see Table 1). This section provides a synthesis of the social factors identified in the literature. Sharaunga and Mudhara (2018), Sheikh, Redzuan, Abu Samah, and Ahmad (2014) and Sithole, Lagat, and Masuku (2014) found that the farmers' age was positively and statistically significant, with older household heads being more likely to participate in collective activities since they had more experience and limited job opportunities. In contrast, Alam, Kobayashi, Matsumura, Eshan, Faridullah, and Siddighi (2012) and Nhundu, Mushunje, Zhou, and Aghdasi (2015) revealed that younger farmers showed higher participation in irrigation management because they could work productively for longer periods than older farmers, which reports that age has a significantly negative effect on

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participation. However, Etwire, Dogbe, Wiredu, Martey, Etwire, Owusu, and Wahagal (2013) and Muchara, Ortmann, Wale, and Mudhara (2014) found that age has no significant influence on the household heads' decision to participate in collective action. In addition, Sserunkuuma, Ochom, and Ainembabazi (2004) revealed that the gender of the farming households' heads could significantly influence their participation in PIM. Balasubramanya (2019) states that farms operated by female workers were significantly less likely to participate in collective action. However, other scholars report that gender does not significantly affect farmers' participation in collective action (Botlhoko & Oladele 2013; Etwire, Dogbe, Wiredu, Martey, Etwire, Owusu, & Wahagal 2013; Muchara, Ortmann, Wale, & Mudhara 2014).

Apart from the above, household size, too, has a significant association with farmer participation (Alam, Kobayashi, Matsumura, Eshan, Faridullah, & Siddighi 2012; Botlhoko & Oladele 2013) because the larger the household size, the greater will be the need for participation of the head of household as more food and other items are consumed daily (Alam, Kobayashi, Matsumura, Eshan, Faridullah, & Siddighi 2012; Sithole, Lagat, & Masuku 2014). Moreover, Alam, Kobayashi, Matsumura, Eshan, Faridullah, and Siddighi (2012) state that family members encourage the head farmer to participate in PIM. Also, some scholars reveal that more years spent in formal education increase farmers' ability to acquire knowledge about irrigation techniques of farming at the plot level, but at the same time, it tends to reduce their involvement in collective action since they have a higher opportunity cost of labour that reduced their household's dependency on farming (Etwire, Dogbe, Wiredu, Martey, Etwire, Owusu, & Wahaga1 2013; Muchara, Ortmann, Wale, & Mudhara 2014; Nhundu, Mushunje, Zhou, & Aghdasi 2015). However, Sserunkuuma, Ochom, and Ainembabazi (2004) explained that educated farmers had more opportunities to arrange alternative income sources. Therefore, they could more easily pay irrigation water fees, resulting in a significant positive effect on participation in PIM.

Additionally, Sserunkuuma, Ochom, and Ainembabazi (2004) found the significant and negative effect of farming experience on farmers' participation in collective action, implying that the result could be positive or negative, depending on whether the farming experience had been good or bad. However, Bhatta, Matsuoka, Sapkota, and Shrestha (2010) reported that an increase in farming experience does not significantly affect farmers' irrigation management decisions. House type also influences farmers' participation. Sheikh, Redzuan, Abu Samah, and Ahmad (2014) and Sserunkuuma, Ochom, and Ainembabazi (2004) found that farmers who lived in brick-and-mortar houses were more likely to participate in collective action. Furthermore, studies by Sharaunga and Mudhara (2018) and Sserunkuuma, Ochom, and Ainembabazi (2004) reveal that insecurity regarding land tenure (tenants) lowers long-term investment in plot management and O&M, which has a significant and negative effect on farmers' participation in irrigation management. In addition, Sserunkuuma, Ochom, and Ainembabazi (2004) found a significant positive relationship between the household dependency ratio (i.e., the total number of child and adult dependents compared to the number of working adults) and farmers' participation in collective action.

The level of participation in collective action also depends on the positive attitude or satisfaction of household heads towards the irrigation system. Upasena and Abeygunawardena (1992) revealed that the negative attitudes of farmers in participating in O&M significantly affect their contribution. Alam, Kobayashi, Matsumura, Eshan, Faridullah and Siddighi (2012) point out that farmers are more satisfied when improved irrigation

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infrastructure and efficient water distribution are available within the system. Similarly, Chandran and Chackacherry (2004) and Gholamrezai and Sepahvand (2017) discovered that a positive attitude or satisfaction towards the irrigation system enhances farmers' participation. Similarly, settler type significantly influences farmers' participation in irrigation management. A study by Upasena and Abeygunawardena (1992) in Sri Lanka, for instance, reveals that older settlers' participation in PIM was significantly lower than that of new settlers in the Kimbulwana Oya scheme.

Table 1: Summary of the effects of social factors on farmers' participation in collective activities studied in the literature

Individual factor	**Direction and degree of factor**	**Author(s) and Year**
Age of household head	Significant positive	Sharaunga & Mudhara (2018), Sheikh et al. (2014), Sithole et al. (2014)
	Significant negative	Nhundu et al. (2015), Wang et al. (2014)
	Positive	Alam et al. (2012), Arun et al. (2012)
	Negative	Bhatta et al. (2010), Chandran & Chackacherry (2004), Etwire et al. (2013)
Gender of household head	Significant positive	Sserunkuuma et al. (2004)
	Positive	Etwire et al. (2013), Muchara et al. (2014), Nhundu et al. (2015)
	Negative	Botlhoko & Oladele (2013), Sithole et al. (2014)
Household size	Significant positive	Alam et al. (2012), Botlhoko & Oladele (2013)
	Positive	Bhatta et al. (2010), Sharaunga & Mudhara (2018)
	Negative	Etwire et al. (2013), Sithole et al. (2014)
Education level of household head	Significant positive	Arun et al. (2012), Gholamrezai & Sepahvand (2017), Nhundu et al. (2015), Sheikh et al. (2014)
	Significant negative	Etwire et al. (2013), Muchara et al. (2014), Nakano & Otsuka (2011)
	Positive	Miao et al. (2015), Sithole et al.(2014)
	Negative	Botlhoko & Oladele (2013), Sserunkuuma et al. (2004)
Farming experience	Significant negative	Sserunkuuma et al. (2004)
	Positive	Bhatta et al. (2010), Botlhoko & Oladele (2013), Chandran & Chackacherry (2004)
House type (Permanent house vs temporary house)	Significant positive	Sheikh et al. (2016), Sithole et al. (2014), Sserunkuuma et al. (2004)
Insecurity of land tenure	Significant negative	Sharaunga & Mudhara (2018), Sserunkuuma et al. (2004)
Household dependency ratio/no. of dependents	Significant positive	Sserunkuuma et al. (2004)
	Negative	Botlhoko & Oladele (2013)

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The positive attitude of PIM	Significant positive	Alam et al. (2012), Chandran & Chackacherry (2004), Gholamrezai & Sepahvand (2017)
Settler type (Traditional farmer vs new settler)	Significant negative	Upasena & Abeygunawardena (1992)

Economic Factors

This section provides a summary of the economic factors identified in the literature. A list of the economic factors that affect farmers' participation in irrigation management is provided in Table 2. Based on the previous research findings, Muchara, Ortmann, Wale, and Mudhara (2014), Sharaunga and Mudhara (2018), and Sithole, Lagat, and Masuku (2014) claim that when the farm size is increased, farmers' participation in collective action also becomes high, resulting in a demand for crop water requirement that grows with the extent of the land. On the contrary, Bhatta, Matsuoka, Sapkota, and Shrestha (2010) highlighted significant negative effects on farmers' satisfaction with increased land size, resulting in water inadequacy and low productivity. In addition, Alam, Kobayashi, Matsumura, Eshan, Faridullah, and Siddighi (2012) and Sharaunga and Mudhara (2018) discovered that a higher return from irrigated agriculture increases the probability of farmers' participation. This is consistent with the findings of Aheeyar (2006), who have reported that farmers who earn a higher income from cash crop cultivation are more likely to participate in PIM.

With regard to the labour force, Alam, Kobayashi, Matsumura, Eshan, Faridullah, and Siddighi (2012) and Sithole, Lagat, and Masuku (2014) pointed out that the head farmer would have more time to engage in O&M when family members are there to contribute their labour. The availability of more household labourers was good when adopting adequate technologies for intensive farming (Bhatta, Matsuoka, Sapkota, & Shrestha 2010). Muchara, Ortmann, Wale, and Mudhara (2014), Nhundu, Mushunje, Zhou, and Aghdasi (2015) and Wang, Chen, and Tao (2014) reported a positive and significant effect on farmers' participation when the number of working adults in the household is high. Besides, Aheeyar (2006) found that household income significantly contributes to farmers' participation. Hence, farmers with higher household incomes are willing to mobilize more resources towards O&M, and it has a significant and positive effect on farmers' willingness to pay for irrigation (Arun, Raj, Kumar, & Kumar 2012). Moreover, Aheeyar, Padmajani, and Bandara (2012) found that the O&M fee significantly and positively affects farmers' willingness to pay for O&M. However, Adekunale, Oladipo, and Busari (2015) shows no significant association between O&M cost and farmers' participation in irrigation management.

Table 2: Summary of the effects of economic factors on farmers' participation in collective action studied in the literature

Individual factor	**Direction and degree of factor**	**Author(s) and Year**
Farm size or cultivated land extent	Significant positive	Arun et al. (2012), Luo et al. (2018), Sharaunga & Mudhara (2018)
	Significant negative	Bhatta et al. (2010), Sithole et al. (2014)
	Positive	Botlhoko & Oladele (2013), Miao et al. (2015), Nakano & Otsuka (2011)

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	Negative	Alam et al. (2012), Etwire et al. (2013), Nhundu et al. (2015)
Income from farming	Significant positive	Alam et al. (2012), Muchara et al. (2014), Sserunkuuma et al. (2004)
	Positive	Botlhoko & Oladele (2013)
	Negative	Sharaunga & Mudhara (2018)
Household labours	Significant positive	Alam et al. (2012), Muchara et al. (2014), Wang et al. (2014)
	Positive	Arun et al. (2012)
Total household income	Significant positive	Aheeyar (2006), Aheeyar et al. (2012), Arun et al. (2012)
Hire labour cost	Significant negative	Adekunale et al. (2015)
O&M fee amount	Significant positive	Aheeyar et al. (2012), Muchara et al. (2014)
	Positive	Adekunale et al. (2015)

Management Factors

The effects of management factors related to farm operation such as tilling, planting, and irrigating on farmers' participation in collective action have not been studied adequately by scholars worldwide. However, some factors related to farm management, such as type of farming full-time versus part-time farming, cropping pattern, level of knowledge on irrigation techniques, and farm management cost, are reported to influence farmers' participation in irrigation management significantly (Adekunale, Oladipo, & Busari 2015; Sithole, Lagat, & Masuku 2014; Sserunkuuma, Ochom, & Ainembabazi 2004).

Sithole, Lagat, and Masuku (2014) observe that farmers engaged in full-time farming are more likely to participate in irrigation management than part-time farmers, supporting the view the type of farming significantly influenced the farmers' participation. In addition, it was found that specific crop type or cropping pattern was significantly associated with farmers' participation. Sserunkuuma, Ochom, and Ainembabazi (2004) indicated that the farmers primarily engaged in paddy farming were more likely to pay irrigation fees in order to reduce the risk of irrigation water shortage. Aheeyar (2006) and Miao, Heijman, Zhu, and Lu (2015) have observed that farmers who cultivate cash crops preferred to participate in collective action since they require reliable water.

Furthermore, Adekunale, Oladipo, and Busari (2015) have found that poor knowledge about farm technology has a significant and negative effect on farmers' participation in irrigation management. Likewise, it was revealed that farm management cost, too, has a significant negative effect on farmers' participation (Alam, Kobayashi, Matsumura, Eshan, Faridullah, & Siddighi 2012, Sserunkuuma, Ochom, & Ainembabazi 2004). This demonstrates that the more costs incurred by the farm O&M than farm profit, the lower the farmers' participation in irrigation activities get (Sserunkuuma, Ochom, & Ainembabazi 2004). This, in turn, discourages such farmers from investing in the farms and expanding their size (Alam, Kobayashi, Matsumura, Eshan, Faridullah, & Siddighi 2012). It has also been revealed that farmers' participation is significantly low when farmers believe that

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cultivation expenses would be higher than the benefits of participation (Sserunkuuma, Ochom, & Ainembabazi 2004).

Table 3: Summary of the effects of management factors on farmers' participation in collective action studied in the literature

Individual factor	Direction and degree of factor	Author(s) and Year
Type of farming (Full-time farming vs part-time farming)	Significant positive	Sithole et al. (2014)
	Positive	Chandran & Chackacherry (2004)
	Negative	Aheeyar (2006)
Cropping pattern or major crop type	Significant positive	Miao et al. (2015), Luo et al. (2018)
Level of knowledge on irrigation techniques	Significant negative	Adekunale et al. (2015)
Farm management cost	Significant negative	Alam et al. (2012), Sserunkuuma et al. (2004)

Institutional Factors

Seven institutional-related factors affecting farmers' participation in irrigation management are presented in the following discussion while indicating whether their influence on farmers' participation is significantly positive or not. According to Alam, Kobayashi, Matsumura, Eshan, Faridullah, and Siddighi (2012) and Muchara, Ortmann, Wale, and Mudhara (2014), farmer training on water/soil management is a critical determinant that enhances farmers' participation in PIM. Gomo, Mudhara, and Senzanje (2014) and Sserunkuuma, Ochom, and Ainembabazi (2004) observe that farmer training would positively change the farmers' perceptions of PIM while enhancing their knowledge of the potential benefits of irrigation. Further, Etwire, Dogbe, Wiredu, Martey, Etwire, Owusu, and Wahaga1 (2013) reported that access to extension services is statistically significant and positive, which indicates that an increase of extension agent contacts increases the probability of farmers' participation in PIM. This finding is consistent with the results of Nhundu, Mushunje, Zhou, and Aghdasi (2015), implying that extension contact allows farmers to acquire more knowledge that supports the coping risk of farming, which results in increased farmers' participation. In contrast, Sithole, Lagat, and Masuku (2014) and Sserunkuuma, Ochom, and Ainembabazi (2004) reveal no significant effect of extension services on farmers' participation.

Moreover, the provision of grain subsidies is one of the institutional factors that has a significant and positive effect on farmers' participation. This is confirmed by Miao, Heijman, Zhu, and Lu (2015), who reveal that intervention of authorities and national policies to provide grain subsidies for farmers will enhance their compliance to irrigation management. Similarly, inputs such as seeds, plants, and fertilizers are delivered through FOs (Arun, Raj, Kumar, & Kumar 2012). Damisa, Abdulsalam, and Kehinde (2008) found that fertilizer availability is vital to improving farmers' satisfaction with irrigation management.

Farmers in an irrigation scheme organize into 3 tiers for decision making and problem-solving at the unit level, block-level, and scheme level (Jinapala, Premadasa, Somaratne, Samad, & Lanka 2010). When the household head has block committee

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membership, the chances of their participation in collective action proved to be high due to a higher level of social capital (Sharaunga & Mudhara, 2018). In addition, Nhundu, Mushunje, Zhou, and Aghdasi (2015) concluded that farmers who have access to credit could overcome financial constraints on farming in terms of production and technology adoption. When institutions or projects serve as guarantors for farmers to access credits, it positively influences their willingness to participate in agricultural projects (Etwire, Dogbe, Wiredu, Martey, Etwire, Owusu, & Wahaga1 2013). Bhatta, Matsuoka, Sapkota, and Shrestha (2010) found a significant and positive effect on the timely availability of canal water on farmers' participation. The findings of a study by Gomo, Mudhara, and Senzanje (2014) also supports the same by showing that farmer satisfaction with irrigation services is significantly lower due to the unreliability of water supply at downstream blocks.

Table 4: Summary of the effects of Institutional factors on farmers' participation in collective action studied in the literature

Individual factor	**Direction and degree of factor**	**Author(s) and Year**
Farmer training	Significant positive	Balasubramanya (2019), Gomo et al., (2014), Nhundu et al. (2015)
Access to extension services	Significant positive	Etwire et al. (2013), Nhundu et al. (2015)
	Positive	Sserunkuuma et al. (2004)
	Negative	Sithole et al. (2014)
Provision of grain subsidies	Significant positive	Miao et al. (2015)
Availability of fertilizer	Significant positive	Damisa et al. (2008), Maskey & Weber (1996)
Block committee membership	Significant positive	Sharaunga & Mudhara (2018)
Credit accessibility	Significant positive	Angella et al. (2014), Etwire et al. (2013), Nhundu et al. (2015)
Canal water availability in time	Significant positive	Bhatta et al. (2010), Damisa et al. (2008), Gomo et al. (2014)

Locational Factors

The following section discusses 5 locational factors studied by previous scholars. Moreover, a list of locational factors affecting farmers' participation in irrigation management is provided in Table 5. The plot location is determined considering the canal distance. Accordingly, scholars determine the plot location according to the canals' head, middle, and tail reach. Arun, Raj, Kumar, and Kumar (2012) and Muchara, Ortmann, Wale, and Mudhara (2014) observed that tail-end farmers' participation is lower than head-end and middle farmers' participation due to severe water deficit. Arun, Raj, Kumar, and Kumar (2012) further state that the probability of farmers' participation in FO becomes significantly lower when the distance to the farm from the main canal is increased. On the other hand, Sheikh, Redzuan, Abu Samah, and Ahmad (2016) pointed out that tail-end farmers participated more in water management to ensure they get their due amount of water since they frequently experience water insecurity. However, Sharaunga and Mudhara (2018) recognized the U-shaped graph representing farmers' participation, implying that middle-section farmers are

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less likely to maintain the irrigation infrastructure than head-end and tail-end farmers due to the water supply pattern.

In addition, plot location in the distributary canal significantly influences farmers' participation in irrigation management. Aheeyar (2006) shows that tail-end farmers in distributary canals were more willing to mobilize cash and materials for O&M than head-enders due to water supply assurance and reliability under bulk water allocation where the pre-agreed volume of water is allocated at the beginning of a cultivation season. Furthermore, Upasena and Abeygunawardena (1992) also found a significant positive effect of plot location along the field canal on farmers' participation in collective action. Moreover, farm distance has a significant impact, implying that farmers residing away from their farms are less involved in collective action (Sheikh, Redzuan, Abu Samah, & Ahmad 2014; Sithole, Lagat, & Masuku 2014). Similarly, Alam, Kobayashi, Matsumura, Eshan, Faridullah, and Siddighi (2012) and Meinzen-dick, Raju, and Gulati (2002) reveal that farmers farther from the market centres are less likely to participate while farmers closer to the market have better economic status and are more likely to participate in PIM.

Table 5: Summary of the effects of locational factors on farmers' participation in collective activities studied in the literature

Individual factor	**Direction and degree of factor**	**Author(s) and Year**
Plot location along with the main canal/ distance from the canal to farm	Significant positive	Chandran & Chackacherry (2004), Sheikh et al. (2014), Upasena & Abeygunawardena (1992)
	Significant negative	Arun et al. (2012), Bhatta et al. (2010)
	Positive	Muchara et al. (2014), Nakano & Otsuka (2011)
Plot location in the distributary canal	Significant negative	Aheeyar (2006)
	Positive	Aheeyar et al. (2012)
Plot location along the field canal/distance along the tertiary canal	Significant positive	Upasena & Abeygunawardena (1992)
	Significant negative	Nakano & Otsuka (2011)
Distance from home to farm	Significant negative	Sheikh et al. (2014), Sithole et al. (2014)
Distance from home to the nearest market	Significant negative	Alam et al. (2012), Angella et al. (2014), Meinzen-dick et al. (2002)

Physical Factors

The identified physical factors are the perception of irrigation water adequacy, soil quality, water shortage severity, and groundwater use (see Table 6). Muchara, Ortmann, Wale, and Mudhara (2014) reveal that farmer participation is significantly influenced by irrigation water adequacy. Adequate water availability increases farmers' satisfaction within the scheme and determines the extent of land allocated for different crop types (Arun, Raj, Kumar, & Kumar 2012). In addition, farmers participate more willingly in irrigation management if they perceive good quality soil in their plots because fertile soil improves production performance and farm profit (Krishna 2013). Accordingly, it was observed that good soil quality significantly influences farmers' participation (Sharaunga & Mudhara 2018).

Furthermore, farmers who experience short-term water scarcity are likely to participate in collective action to minimize the risk of crop losses and improve access to the

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resource (Muchara, Ortmann, Wale, & Mudhara 2014). But when water scarcity persists over long periods, it discourages the active participation of farmers in the collective action (Muchara, Ortmann, Wale, & Mudhara 2014). Supporting this observation, Arun, Raj, Kumar, and Kumar (2012), too, have reported that the probability of participation of farmers who face severe water shortages is low. Sheikh, Redzuan, Abu Samah, and Ahmad (2014) have pointed out that the heavy use of groundwater and better groundwater quality will affect farmers' participation in irrigation management negatively and significantly. This is confirmed by Arun, Raj, Kumar, and Kumar (2012), who find that tube well owners did not participate in FO activities.

Table 6: Summary of the effects of physical factors on farmers' participation in collective activities studied in the literature

Individual factor	Direction and degree of factor	Author(s) and Year
Perception of the irrigation water adequacy	Significant positive	Chandran & Chackacherry (2004), Muchara et al.(2014)
Perception of soil quality	Significant positive	Sharaunga & Mudhara (2018)
Water shortage severity	Significant positive	Sharaunga & Mudhara (2018)
	Significant negative	Wang et al. (2014)
Use of groundwater	Significant positive	Sheikh et al. (2014)
	Positive	Arun et al. (2012)

Methods to Assess Farmers' Participation in Collective Action

Data were collected using a structured questionnaire and in-person interviews with selected households' head farmers for many cross-sectional studies done by previous scholars (Alam, Kobayashi, Matsumura, Eshan, Faridullah, & Siddighi 2012; Nhundu, Mushunje, Zhou, & Aghdasi 2015). Moreover, the researchers chose the multi-stage random sampling technique as it is the most popular sample frame to collect data from the farmers engaged in irrigated farming (Arun, Raj, Kumar, & Kumar 2012; Etwire, Dogbe, Wiredu, Martey, Etwire, Owusu, & Wahaga1 2013; Sharaunga & Mudhara 2018). Similarly, Logit, Probit, Tobit, and Multiple regression analysis were the commonly used statistical methods in the literature to assess the direction and degree of each factor affecting farmers' participation (Botlhoko, & Oladele 2013; Chandran & Chackacherry 2004; Luo, Wang, Sun, Xu, & Sun 2018).

Moreover, in statistical analysis, many studies have considered farmer participation as a dependent variable and the factors as independent variables. Botlhoko and Oladele (2013), Etwire, Dogbe, Wiredu, Martey, Etwire, Owusu, and Wahaga1 (2013), Nhundu, Mushunje, Zhou, and Aghdasi (2015), Sharaunga and Mudhara (2018) and Sithole, Lagat, and Masuku (2014) defined farmer participation as a discrete choice or dummy dependent variable assuming the value of 1 for the participant, and 0, otherwise. In contrast, Alam, Kobayashi, Matsumura, Eshan, Faridullah, and Siddighi (2012), Muchara, Ortmann, Wale, and Mudhara (2014) and Sheikh, Redzuan, Abu Samah, and Ahmad (2014) applied Participation Index (PI) to measure the level of farmer participation by recognizing a list of activities that farmers are engaged in. Alam, Kobayashi, Matsumura, Eshan, Faridullah, and Siddighi (2012) developed

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a PI by calculating the average difference between the number of respondents involved in PIM and those not involved in PIM. Further, a score has been used to determine the level of farmers' participation at the main canal, watercourse, and field canal level based on the three-point scale. However, the uncertainty level with this measure is high since each farmer is required to participate in more than one activity such as water allocation, field canal O&M, revenue collection, and dispute resolution at distributary and field canal levels under the PIM.

Muchara, Ortmann, Wale, and Mudhara (2014) argue that farmers in an irrigation scheme are engaged in many collective activities, and therefore, farmer participation cannot be considered a binary choice. Consequently, it is required to find the composite index by measuring the frequency counts of all collective activities in which each farmer participated. Accordingly, as per Muchara, Ortmann, Wale, and Mudhara (2014), Principal Component Analysis (PCA) was used to derive the composite index of participation, ranking farmer participation in a selected number of collective activities by using a five-point Likert scale ranging from 0 (poor) to 4 (excellent). Similarly, Arun, Raj, Kumar, and Kumar (2012) have developed PI by using standard weights for each activity with the help of 15 subject matter specialists. Then, the scores were obtained for each farmer based on the number of activities they participated in; they were categorized into 2 groups, namely, active and inactive participation.

The Knowledge Gap

A limited number of studies could be found where data had been analysed from cross-sectional surveys in Pakistan, India, Tajikistan, South Africa, Ghana, Iran, China, Zimbabwe, Swaziland, and Uganda. Thus far, no research has been conducted to assess factors affecting farmers' participation in collective action in Sri Lanka. According to the available literature, the influences of social and economic factors on farmers' participation have been widely researched, while other factors such as managerial, institutional, locational, and physical factors have not received sufficient attention.

Of the 36 factors we found, 17 factors had been studied only rarely, and by no more than 1 or 2 scholars; hence, it is hard to determine the influence of those factors on farmer participation according to their degree of influence (i.e., high, medium, and low). The absence of a proper conceptual framework for many studies made it impossible to discover any significant findings, resulting in increased uncertainty about the adequacy of the existing studies. Moreover, the synthesis of results shows that sometimes the direction and significance of the same factor vary from study to study, even in similar studies. This happened, most probably, due to the application of different methods with different levels of certainty.

Moreover, the effects of some factors were inconclusive since they have been considered as a whole. Soil quality, for instance, has been identified as a factor that has a significant effect on farmers' participation, while the effect of soil salinity and soil type on farmers' participation has not received any attention. Similarly, no attempt has been made to examine the effect of farming expenditure on farmers' participation, although the income from farming has been identified as one of the significant factors affecting farmers' participation. Therefore, the findings of the limited volume of the existing literature are not adequate to better understand the effect of various factors that influence farmers' participation in collective action. By identifying these limitations, this study suggests

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appropriate determinants and measures to assess tail-end farmers' participation in PIM, where irrigation management failures exist.

Proposed Determinants and Measures to Assess Farmers' Participation in PIM

A conceptual framework for assessing farmers' participation in PIM is proposed in this paper (see Figure 3), based on the factor analysis results of previous literature in this area. Accordingly, 36 factors that have been reported as significant association with farmers' participation were selected and organized meaningfully by categorizing all of them into two main categories and several subcategories. Accordingly, the framework includes 10 social factors, 6 economic factors, 4 management factors, and 7 institutional factors under the non-spatial category, while 5 locational factors, and 4 physical factors under the spatial category. Moreover, it is essential to note that the proposed determinants may have some limitations because the factors affecting tail-end farmers' participation may differ from one location to another in terms of the irrigation management models and locality, as proved by previous studies. Furthermore, a factor that is found to enhance farmers' participation in one irrigation scheme at one particular time might discourage participation in another irrigation scheme at the same time. Therefore, further research in Sri Lanka is needed to confirm the consistency of influence of these proposed factors.

Table 7 shows different methods that can be applied to determine farmers' participation in PIM. Many scholars use proportional methods as it is the most common method applied to examine farmer participation in collective activities (Alam, Kobayashi, Matsumura, Eshan, Faridullah, & Siddighi 2012; Muchara, Ortmann, Wale, & Mudhara 2014; Sheikh, Redzuan, Abu Samah, & Ahmad 2016). However, researchers can use any of the following methods after assessing their validity and reliability, if possible, or according to their preference. The proposed methods would help researchers determine the accuracy of their results. The authors propose the proportional and distributional methods as appropriate measures to assess farmers' participation in PIM in Sri Lanka based on the validity and utility effectiveness as described in Table 7, based on previous scholars' analytical interpretation as discussed earlier.

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Figure 3: The proposed conceptual framework of factors affecting farmers' participation in PIM

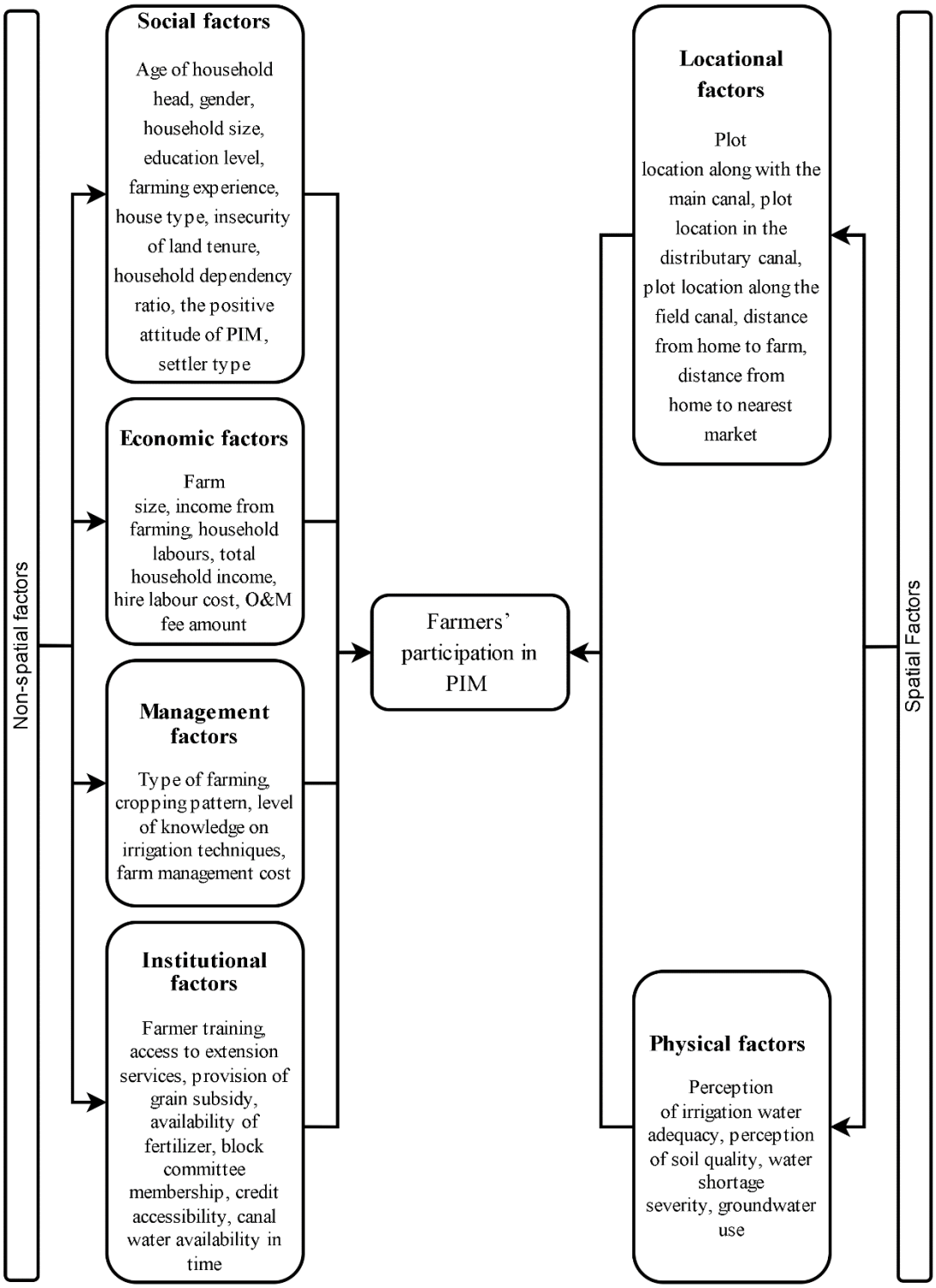

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Table 7: Different methods to determine farmer participation in PIM

	Accounting	**Proportional (Method I)**	**Proportional (Method II)**	**Distributional**
Measurement issue	Any activity related to farmer participation in PIM	The dichotomous measure of farmer participation in PIM	Scaling and indexing farmer participation in collective activities	Categorized farmer participation according to the distance to the canal (i.e., head, middle, and tail)
Unit of measurement	Individuals	Number of collective activities in which the farmer participates	Frequency count of farmer participation in collective activities	The spatial pattern of irrigated plot owners' participation
Cost	Low	Moderate	Moderate to high	High
Ease of use	Easy	Easy	Moderately difficult	Moderately difficult
Utility effectiveness	Low for participation evaluation	Moderate for participation evaluation	Good for examining PIM performance in a given location	Good for evaluating the area-specific potential for PIM development
Validity	Low	Moderate	Moderate to high	High
Sample frame	None: count participants	Random, a proportionate number of households, based on the population	Random, a proportionate number of households, based on the population	Spatially selected irrigation plot owners along with the canal system
Required disciplinary mix	None: any discipline can serve	Specific discipline in conjunction with other sciences	Specific discipline in conjunction with other sciences	Specific methods of interdisciplinary approach must be utilized

Note. Adapted from "Practical Consideration in Assessing Barriers to IPM Adoption" by P. Nowak, S. Padgett, and T.J. Hoban, 1996, United States Department of Agriculture, p. 101. Copyright 1996 by the United States Department of Agriculture**.**

CONCLUSION

Although many issues are associated with the irrigation schemes in Sri Lanka, an analysis at the household level to measure the influence of factors affecting farmers' participation in PIM, especially at the tail-end of irrigation schemes, does not currently exist. Based on the previous empirical research evidence, this study finds that 36 factors significantly influence

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farmers' participation in collective activities. This includes 10 social factors, 6 economic factors, 4 managerial factors, and 7 institutional factors under the non-spatial category. Five locational and 4 physical factors are included in the spatial category. Moreover, this study finds 4 methods that can be applied to determine farmers' participation in PIM.

This study makes several contributions to PIM research. First, this study provides a methodological framework for systematically assessing farmers' participation in PIM consisting of major episodes: establishing study context, literature review, data collection and analysis. Second, this study recommends distributional and proportional measures to assess the factors affecting farmers' participation in PIM as the measures are valid for examining PIM performance and evaluating any area-specific potential for PIM development. All the proposed determinants and measures will contribute to a better understanding of the effects (i.e., direction, degree, and significance) of non-spatial and spatial factors on tail-end farmers' participation in PIM. Moreover, it is expected that this study will extend the scope of dimensions pertaining to farmers' participation in collective activities, especially at the tail-end of irrigation schemes, not only in Sri Lanka but also in other countries where IMT or PIM is being implemented. Third, this study presents detailed and sufficient information in order to make the conceptual framework and methodology replicable for future research. The proposed conceptual framework makes it easier to compare the relationships between different factors and identify any combined influences on farmers' participation in PIM. Moreover, the proposed determinants and measures would be the best framework for further research in Sri Lanka and other developing countries.

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ABOUT THE AUTHORS

LGDS YAPA
Geography Section
School of Humanities
Universiti Sains Malaysia, Penang
sewwandiyapa87@student.usm.my
and,
Department of Geography
Faculty of Humanities & Social Sciences

e-Bangi Faculty of Social Sciences and Humanities Universiti Kebangsaan Malaysia
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University of Ruhuna, Sri Lanka
syapa@geo.ruh.ac.lk

ANISAH LEE ABDULLAH
Geography Section
School of Humanities
Universiti Sains Malaysia, Penang
anisah@usm.my

RUSLAN RAINIS
Geography Section
School of Humanities
Universiti Sains Malaysia, Penang
rruslan1609@gmail.com

GPTS HEMAKUMARA
Department of Geography
Faculty of Humanities & Social Sciences
University of Ruhuna, Sri Lanka
sam@geo.ruh.ac.lk