Adaptation and Effectiveness of Integrated Pest Management (IPM) Practices in Paddy Cultivation in the Southern Province of Sri Lanka

Bachelor's Thesis

Climate Smart Agriculture

Spring 2025

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HAMK
Häme University
of Applied Sciences

Abstract

DP Climate Smart Agriculture
Author Kalhari Iranthika Liyanage Year 2025
Subject Adaptation and Effectiveness of Integrated Pest Management (IPM) Practices in Paddy Cultivation in the Southern Province of Sri Lanka
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Paddy cultivation continues to be the foundation of Sri Lanka's agricultural economy and food security, particularly in the Southern region. Nevertheless, increased dependence on chemical pest control has sparked serious debates on environmental pollution, ill-health implications on farming community, and sustainability of agricultural systems over time.

This thesis investigates the uptake and success of IPM as a sustainable option in paddy cultivation. Using a mixed methods research framework, the study combines quantitative responses from a survey of 62 farmers with qualitative data collected through interviews with agricultural instructors. This report reveals that when IPM is used, pesticide use is reduced, crop yields increase, there is less risk to farmer health, and there are positive effects on the environment. However, several obstacles such as farmers' low recognition, insufficient training and infrastructure weaknesses hinder the more widespread deployment of IPM technologies.

The study underscores the crucial importance of enhanced institutional support, broad-based farmer education programs and focused policy interventions to push the shift towards sustainable pest management. Amidst rapidly accelerating climate change, increasing ecological fragility, the rampant spread of pests and diseases, reduced access to agrochemicals, and people's decreasing purchasing power, the mass adoption of IPM is highlighted as a central strategy in safeguarding the resilience, productivity and sustainability of Sri Lanka's agricultural sector.

Keywords Integrated pest management, southern province, paddy, farmer, Agriculture department

Pages 63 pages and appendices 02 pages

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Abbreviations

IPM	Integrated Pest Management
DOA	Department of Agriculture
AI	Agriculture Instructor
SL	Sri Lanka
SP	Southern Province
PPS	Plant Protection Service
Bt	Bacillus thuringiensis

1 Introduction

Paddy cultivation is a heart of Sri Lanka's agricultural sector, mostly in Southern, Northcentral, and northwestern of Sri Lanka which providing both economic stability and nutritional security for the country population. However, the combination of traditional farming methods with adding more chemical pesticide leads to have more concerns regarding environmental degradation, farmer health, and long-term sustainability. This shows that the requirement of an Integrated Pest Management (IPM) system to the country like Sri Lanka which offers a sustainable alternative by combining biological, physical, cultural, and limited chemical practices to manage pest populations in ecologically and environmentally friendly.

This study explores the adoption and efficacy of IPM in Sri Lankan paddy cultivation by synthesizing current literature and case studies. The findings shows that while IPM adoption is supported by country, government bodies, NGOs, and international organizations, challenges such as lack of training, limited farmer awareness, and dependency on chemical inputs continue to block the implementation. With these barriers, IPM has already demonstrated considerable, measurable and significant benefits in agriculture, including considerable cost reductions, improved farmer health and safety, enhanced crop quality and the production, and environmental sustainability.

This study highlights that expanding IPM practices in Sri Lankan agriculture industry requires stronger institutional support, grassroots-level education for the farmers, and the upgrade & modernize of the infrastructure to ensure farmers can access and apply sustainable pest management practices precisely and accurately. As climate change and food security requirement increase, integrating new technologies like IPM into mainstream paddy cultivation is not only an ecological impact or improvement but an economic necessity for the adaptability of Sri Lankan agricultural sector.

2 Research

2.1 Background

The Southern Province of Sri Lanka functions as a perfect spot to study the implementation and performance of Integrated Pest Management (IPM) practices throughout paddy farm cultivation (Jayasooriya & Aheeyar, 2016). Integrated Pest Management has proven itself as a long-lasting pest management solution because it tackles the problems from chemical pesticide overuse of both environmental health and economic viability while protecting human well-being (Barzman et al., 2015).

Sri Lanka's agricultural background shows a growing trend of adopting chemical pest management practices instead of sustainable instinctive pest control methods (Jayasooriya & Aheeyar, 2016). The latest research confirms the significant expansion of chemical pesticides in all agricultural production operations including paddy fields (Prodipto et al., 2023).

Integrated Pest Management offers a far-reaching way to deal with pest control, combining social, organic, mechanical, and substance techniques to maintain pest populaces underneath financially damaging levels (Pretty & Bharucha, 2015). IPM has been effective in minimizing the use of pesticides, lowering the cost of crops, and enhancing agrarian sustainability in countries all over the globe (Campos et al., 2018).

The Southern Province shows both positive opportunities and challenging obstacles to implementing IPM practices because of its multiple agricultural zones and its strong reliance on paddy farming. The ranchers who practice traditional farming methods in this area need access to modern pest management strategies while facing major obstacles in transitioning to sustainable practices (Jayasooriya & Aheeyar, 2016).

IPM practice adoption in paddy agriculture performs dual roles by delivering technological development and financial advancement. IPM requires substantial progress in delivering economic benefits such as decreased costs and increased yield and environmental sustainability improvements to ranchers (Jayasooriya & Aheeyar, 2015).

Talking about Integrated Pest Management practices in paddy cultivation demonstrates great progress toward sustainable horticulture development in Sri Lanka. The Southern

Province, with its rich rural practice and pressing requirement for innovative pest management arrangements, offers a fruitful ground for studying the adaptation and effectiveness of IPM (Jacquet et al., 2022). By addressing the difficulties and leveraging the open doors related to IPM, the district can start a trend for sustainable pest management practices that balance financial, ecological, and social contemplations (Jayasooriya & Aheeyar, 2015).

2.2 Research problem

The horticultural area in Sri Lanka, especially paddy cultivation, has experienced various difficulties because of the steady dependence on compound pesticides for pest management. The over-the-top utilization of synthetic pesticides has prompted a bunch of unfriendly results, including ecological debasement, the improvement of pest opposition, resurgence of pest populaces, and the rise of optional pests (Horgan & Kudavidanage, 2020). These issues have compromised the sustainability of agrarian practices as well as forced critical wellbeing gambles on ranchers and buyers the same, stemming from pesticide buildups in food and the climate. Furthermore, the monetary weight on ranchers has risen because of increased costs related to the abuse of compound pesticides. Although there has been a try to adopt voluntary measures such as Integrated Pest Management (IPM), their adoption in paddy farming has been low in some regions, such as the Southern Province of Sri Lanka (Jayasooriya & Aheeyar, 2016).

Problems with respect to certain factors have hindered IPM from being applied widely as a sustainable pest management tool that harmonizes organic methods with social and synthetic methods (Horgan, 2017).

Ranchers face several barriers in IPM implementation because they lack information and mindfulness and receive insufficient training while finding limited access to resources along with their continued usage of synthetic chemicals for their quick effect. The execution results of Integrated Pest Management practices vary based on farmer dedication and environmental conditions together with the integration possibilities between new and established agricultural methods (Midega et al., 2018).

The struggle to solve these problems has intensified for paddy cultivating communities who use this agriculture as their main occupation in the Southern Province of Sri Lanka. Numerous challenges in implementing IPM into this environment persist because of insufficient research about its practicality in this context. Thus, the need to assess the existing reception levels of IPM practices, evaluate their effectiveness in reducing pest-related harms, and comprehend the financial and ecological effects of these practices is fundamental (Dissanayake et al., 2019). Such exploration is fundamental to giving insights into the capability of IPM as a sustainable option in contrast to customary pest control techniques and to distinguishing noteworthy systems for enhancing its reception in the locale (Pretty & Bharucha, 2015).

Additionally, information on ideas of ranchers to beat the obstructions that they experienced in adopting IPM strategy (or non-substance pest controlling techniques in general) was gathered. By following the comparable technique utilized in the applications of boundaries, ideas for promoting IPM in vegetable cultivation were too distinguished (Vignola et al., 2015).

3 Literature Review

3.1 Sri Lanka paddy cultivation

Rice ranks as the leading crop worldwide because more than fifty percent of human beings depend on it as their basic food (Mohidem et al., 2022). Worldwide rice cultivation consists of Oryza sativa as the leading species throughout Asia, but Oryza galleria remains popular for West African cultivation. Asian societies have been using rice as their cultural foundation for hundreds of years since the time it became their essential food staple while shaping their economic activities and their nutritional diet. Rice cultivation in Sri Lanka extends throughout its Asian heritage because this crop supports the economic lives of its population (Fukagawa & Ziska, 2019).

The people of Sri Lanka rely on rice as both their main dietetic substance and a fundamental force within their agricultural economic framework. Nearly all Sri Lankans consume rice daily because the typical individual spends 107 kilograms of rice each year. Sri Lankans rely intensively on rice as their main dietary staple thus maintaining the necessary food security for its population (Perera & Prashantha, 2022). Rice serves as a fundamental food source and at the same time provides an essential component to Sri Lankan nutrition because it supplies 45% of daily calories and 40% of daily protein needs. Rice stands as the main nutritional source for affordable and accessible food consumption among the general population. (Jayatissa, Wickramasinghe, & Piyasena, 2014)

Rice farming runs as a major cultural tradition throughout the entire history of Sri Lanka. Traditional farming approaches linked to native understanding have safeguarded rice cultivation systems across multiple generations. The island nation has favourable environmental conditions and a location to grow rice through distinct seasons called Maha and Yala (Rambukwella & Priyankara, 2016). Rice cultivation during the Maha season, which runs during monsoon times produces most of the paddy output yet farmers in the Yala season rely heavily on irrigation systems for crop growth. The regular rice cultivation schedule allows farmers to sustainably produce rice always to furnish a reliable rice supply throughout each year (Dharmasena, 2010).

The paddy cultivation sector in Sri Lanka confronts multiple obstacles even though it represents a vital sector. Traditional farming practices combined with climate changes create challenges that poison rice farming sustainability while decreasing its productivity (Dharmasena, 2010). Rice farmers encounter substantial threats from unexpected weather patterns which bring both dry spells combined with flooding events thus affecting agricultural seasons and resulting in harvest reduction. Modern farming practices are reliant on chemical fertilizers but also pesticides have triggered concerns about environmental degradation while harming soil health which drives producers to consider organic farming approaches and Integrated Pest Management (IPM) (Hitihamu & Susila, 2012).

Proper management of water during paddy cultivation stands as a fundamental requirement in Sri Lankan farming operations (Rambukwella & Priyankara, 2016). Rice farming receives sustained support from the irrigation systems that early civilizations built including tanks and canals during ancient times. The ancient irrigation systems maintain their essential role in managing water resources especially during the dry period. The growing water requirements from other sectors and the current water management inefficiencies obstruct the sufficient irrigation of Sri Lankan paddy fields. Modernization of irrigation systems plus effective water management education of farmers represents the solution to current water resource challenges (Fukagawa & Ziska, 2019).

Development of rural socioeconomic conditions in Sri Lanka directly correlates with rice cultivation activities (Mohidem et al., 2022). More than half of the rural people generate their living through paddy cultivation practices. As a lifestyle, numerous people find more than monetary benefits since paddy farming unites them with their cultural legacy. Various agricultural organizations together with the government have created multiple programs focused on assisting paddy farmers by providing seed and fertilizer subsidies as well as assured product buying prices. These initiatives aim to enhance rice cultivation profitability and stimulate youth involvement in agriculture as a professional field (Jayatissa, Wickramasinghe, & Piyasena, 2014).

3.2 What is IPM

Integrated Pest Management (IPM) presents an integrated pest control approach that unites multiple methods to fight pests while protecting the environment and economic value (Das et al., 2024). IPM deviates from standard pest control methods because it merges numerous tools and various techniques to handle pest challenges through a total ecological system. IPM develops pest prevention methods to minimize ecosystem harm and defend people's wellness and conserve the natural balance between pests and their environment (Deguine et al., 2021).

IPM's fundamental principle is to use available natural pest management systems to their maximum extent (Jeffers & Chong, 2021). Natural pest regulators such as weather conditions and predators together with parasites and pathogens function to control pest populations in the environment. The utilization of pest control approaches found in nature through IPM reduces the necessity for external intervention and therefore decreases chemical pesticide dependence. This method defends important ecosystem organisms and minimizes pests' ability to become resistant to chemical applications while protecting the environment (Zhou et al., 2024).

The core objective of physical controls in IPM programs consists of blocking pests from accessing target crop areas and other important locations (Cherlinka, 2020). Typical physical pest management methods use barriers and traps and mechanical systems to eliminate pests from their habitats. Physical pest management strategies include the use of nets as crop protectors against birds and placement of traps to catch rodents thus demonstrating practical methods which cause no environmental damage. The practice of habitat modification plays an essential role in pest control because it changes environmental conditions to decrease pest habitation areas. The combination of crop rotation together with appropriate irrigation systems and well-maintained soil reduces pest populations by breaking their developmental patterns along with disrupting their habitats (Deguine et al., 2021).

limited use of chemical control in IPM occurs only when pest management strategies fail yet require specific intervention (Torres & Bueno, 2018). The strategy focuses on employing toxic-free pesticides in specific deployment to protect non-target living things together with environmental elements. The implementation of chemical treatments in Integrated Pest Management (IPM) follows necessary use criteria decided after systematic monitoring and decision-making procedures. The specific application of chemicals in IPM takes place only after other methods prove ineffective and when crop integrity and growth need protection (Green, Stenberg, & Lankinen, 2020).

Success in IPM directly depends on accurate monitoring and appropriate decision-making processes (Angon et al., 2023). Farmers together with pest managers consistently monitor pest populations along with their behaviour while recording their environmental habitat information. They can select the best pest control strategy through precise identification of pest type and lifecycle understanding. Intervention happens beforehand to prevent pest problems from growing into critical infestations, so farmers require minimal drastic measures (Zhou et al., 2024).

IPM leads to important environmental sustainability through its implementation (Cherlinka, 2020). Through its reduction of chemical pesticide usage IPM protects biodiversity because it prevents soil and water contamination as well as air contamination. The reduced chance of pesticide residues in food provides consumers with safer methods of consumption. IPM supervises pest management through effective solutions because pests find it harder to develop resistance when integrated pest management techniques are used compared to standard pest control systems (Green, Stenberg, & Lankinen, 2020).

Economic feasibility is one of the essential benefits that IPM provides (Torres & Bueno, 2018). The process of adopting IPM approaches at first demands extra specialist know-how together with greater effort, yet eventual cost savings and substantial advantages become apparent in the prolonged period. The practice of IPM helps farmers decrease their expenses on chemical inputs while simultaneously avoiding costly pest outbreaks which consequently reduces their production expenses. The implementation of sustainable farming practices together with improved crop health results in increased harvest quantity as well as superior quality production which increases both market value and profitability in agricultural enterprises (Das et al., 2024).

3.3 IPM in Sri Lanka

Sri Lanka adopts Integrated Pest Management (IPM) as an ancient farming practice that connects to traditional agricultural methods which focus on maintaining harmony between humans and nature (Van, Senarath, & Amarasinghe, 2004). During ancient times farmers-controlled pests using three methods which included crop mixing techniques and pesticide utilization of natural predators and organic substances. Traditional practices in ancient times now form the basis for present-day modern IPM methods which combine productivity enhancements with sustainability goals (Jayasooriya & Aheeyar, 2015).

Notion of IPM began to spread across Sri Lanka during the 1980s as part of modern times (Angon et al., 2023). The first IPM extension program cantered on rice crops became part of national policy in 1984 through its nationwide implementation. Effectively controlling pests became accessible to farmers through implementation of the Training and Visit extension system within this program. The introduction of this program marked a major advancement in building systematic scientific pest management methods specifically for rice farming since rice represents the backbone of Sri Lankan agriculture and serves as a staple crop (Dissanayake et al., 2019).

Multiple organizations alongside governmental institutions within Sri Lanka provided essential backing to IPM promotion activities (Pretty & Bharucha, 2015). The implementation of IPM programs throughout Sri Lanka depends on the collaboration between the Department of Agriculture and Provincial Agricultural Departments and Mahaweli Authority of Sri Lanka. The government entities have distributed essential resources together with specialized technical support and educational training to help farmers adopt IPM practices throughout the country. The Plant Protection Service (PPS) joins forces with IPM-related pest control method development as their focus (Jayasooriya & Aheeyar, 2015).

The development of IPM in Sri Lanka received important support from both non-government organizations and private industry players (Dissanayake et al., 2019). Hayleys along with CropLife and Sarvodaya and the Red Cross alongside CARE execute training sessions and awareness programs which teach farmers about IPM advantages. As well as pest control, these initiatives teach participants about IPM's diverse ecological and farm health and environmental sustainability aspects. These organizations contribute to closing knowledge gaps and resource deficiencies especially within rural and less developed geographical areas of Sri Lanka.

International projects represent an essential element that drove IPM development in Sri Lanka (Pretty & Bharucha, 2015). The Food and Agriculture Organization (FAO) together with the Japan International Cooperation Agency (JICA) have brought worldwide best farming practices and modern agricultural technology to local farming communities through their projects. The launched projects delivered training and equipment and monetary backing to assist in strengthening IPM implementation, especially for paddy growers. The alliance of international partners with Sri Lankan entities has built a comprehensive system for sustainable IPM practice adoption (Jayasooriya & Aheeyar, 2015).

Sri Lankan farmers use rice as their main agricultural practice while IPM initiatives receive their central attention (Dissanayake et al., 2019). Training programs have instructed farmers to recognize natural pest control elements that consist of beneficial insects and pathogens so they can substitute these methods instead of chemical pesticides. Better irrigation methods together with rotation systems and rice varieties resistant to pests have become vital pest population control methods. Through these agricultural practices farmers have enhanced rice yields while securing sustainable farming at its core (van, Senerath, & Amarasinghe, 2004).

Sri Lanka IPM serves as a major accomplishment by leading to reductions in dangerous chemical pesticide applications (Jayasooriya & Aheeyar, 2015). Farmers implementing IPM approaches successfully decrease their operational expenses and decrease pollution impact on the environment while ensuring lower pesticide-related health hazards to themselves. Through adopting sustainable farming practices, farmers have protected biodiversity alongside maintaining ecological health in agricultural areas (Pretty & Bharucha, 2015).

The adoption of IPM methods in Sri Lanka encounters multiple problems although overall implementation remains successful. Several areas tolerate low IPM practice adoption because their farmers lack the necessary resources, and they show limited knowledge of biological pest management while having insufficient farming education (Angon et al., 2023). The continued reliance on chemical pesticides remains a substantial obstacle because some farmers do not know about other pest management alternatives. All farmers need better access to education and research-based infrastructure for implementing Integrated Pest Management solutions through sustained investments (Jayasooriya & Aheeyar, 2015).

3.4 Benefits of IPM for a paddy farmer

Integrated pest management (IPM) can be beneficial in numerous ways to farmers of paddy, like in cost reduction, improved health benefits, and sustainable environments. Practice of IPM enables farmers to use fewer chemical pesticides, thereby saving money and the capacity to build a sustainable agricultural system (Zhou et al., 2024). IPM proves itself a practical method of modern paddy cultivation through the dual set of visible and invisible advantages it delivers (Shrestha et al., 2024). IPM systems help paddy farmers decrease their expenses that stem from pesticide consumption (Padmajani, Aheeyar, & Bandara, 2014). High costs of using chemical pesticides deter farmers because pest resistance develops as an effect of overuse. The IPM system uses biological physical and cultural management practices which allow nature-based pest population control components. Paddy farmers who decrease their pesticide applications succeed in reducing their expenditures and attaining equal or superior agricultural output levels. The economic benefit provides essential support to small farmers who rely on paddy cultivation to survive since they consistently have limited budgets (Dhakal & Poudel, 2020).

IPM practices develop multiple advantages for farmer health while simultaneously creating economic savings. Standard pesticide applications through chemicals result in dangerous substance exposure that causes immediate or extended health difficulties including respiratory complications and skin reactions and potentially leads to cancer development. lower intervention with chemicals becomes necessary when farmers use IPM methods, and this leads to less pesticide exposure to the fields (Das et al., 2024). The agricultural ecosystem becomes safer for farmers through this change because both their health and working environment improve, thus benefiting the entire farming community (Pathak et al., 2022).

The implementation IPM creates important environmental advantages that create positive results for paddy farmers (Fahad, 2020). Soil degradation and water contamination together with harm to beneficial insects and wildlife occur because of excessive chemical pesticide application. Through IPM, farmers learn to protect the environment with safe pest management techniques like predator introduction and ecological pest control interventions. The implemented methods simultaneously protect water resources, maintain environmental stability and maintain soil health. Sustainable paddy farming depends on healthy ecosystems that provide future opportunities for rice cultivation without environmental depletion (Shrestha et al., 2024).

IPM enhances pest management operations through its implementation. IPM employs an integrated method of pest management because it avoids reliance on restricted pesticides like conventional systems do (Gamage et al., 2023). Farmer training includes pest population monitoring combined with the identification of separate pest species followed by targeted control procedures activated only under necessary conditions. The exact application of IPM techniques eliminates inexperienced interventions while maintaining pest susceptibility to other control methods. The pest control techniques become both effective and enduring when farmers implement this approach which decreases the potential for pest outbreaks that threaten their crops (Deguine et al., 2021). Better-quality paddy emerges as one of the benefits that results from implementing IPM practices. The direct application of excessive chemical pesticides results in crop surface residues which degrade both crop quality standards and market prospects. Through IPM farmers gain the ability to produce pesticide-free rice suitable for the growing market that wants safer and healthier commodities. The reputation improvement of farmers benefits consumers and creates new market prospects for trade that leads to increased income potential in both domestic and worldwide markets. (Dhakal & Poudel, 2020)

IPM creates a platform through which farmers actively share information while strengthening their capabilities. Adoption of IPM depends on acquiring specific training and understanding through workshops as well as training programs and farm field schools (Padmajani, Aheeyar, & Bandara, 2014). This program gives farmers the tools necessary to take well-informed actions regarding pest control. Farming communities gain from collaboration thanks to knowledge exchange programs that promote ongoing teaching and novel discoveries. The joint efforts among paddy farmers result in collective agricultural strength that protects them from both pest-related difficulties and climate change problems (Deguine et al., 2021). The IPM approach upholds goals related to sustainable agricultural systems. The integration of IPM within paddy farming supports current sustainability initiatives that combine economic development of small-scale farmers with minimized environmental impact. Sustainable farming methods prove essential for continuing food safety along with conserving species diversity while combating climate-related issues making the entire agricultural system stable and robust (Pathak et al., 2022).

3.5 IPM methods

The IPM system provides farmers with various environmentally safe pest management tools helping them protect their crops effectively while reducing ecological damage (Zhou et al., 2024). Different combinations of IPM techniques serve various farmers because they address their distinct pest problems combined with their regional environmental conditions. The methods integrate pest control strategies with the essential elements of sustainable ecosystems (Thakur, Sharma, & Sharma, 2021).

The core element of IPM comprises cultural methods that modify farming practices to avoid pest invasion. The disruptive impact on pests stems from techniques that combine rotating crops with proper time scheduling and field maintenance to cut off pest reproduction sequences (Adhikari, 2022). The practice of crop rotation interrupts pest populations that depend on continuous planting of one specific crop and well-timed plantings help prevent pests from reaching peak numbers. Geographic sanitation practices that remove field residues alongside weed matter disrupt pest breeding sites which help decrease population numbers. The basic preventive approaches work efficiently to prevent the necessity of supplemental interventions (Bashyal, Poudel, & Gautam, 2022).

The implementation of IPM depends heavily on physical and mechanical control methods. Both barriers and traps along with manual pest removal form part of the pest control methodologies. Farmer strategies include nets with screens for preventing pest access and sticky traps for catching flying insect pests. Small-scale farmers engage in manual pest removal of caterpillars and beetles as a time-consuming yet useful method for their operations (Thakur, Sharma, & Sharma, 2021). The eco-friendly pest control methods offer non-toxic and environmentally safe solutions that make them perfect choices for such purposes (Adhikari, 2022).

The reduction of pest damage depends on using crops and pest genetic traits through genetic methods. Scientists try to prevent pest damage by developing resistant plant varieties and implementing controlled reproduction of infertile pest insects to decline their wild populations (Alphey & Bonsall, 2018). Through these modern techniques pest control professionals can both solve long-term pest problems while diminishing use of chemical pesticides (Thakur, Sharma, & Sharma, 2021).

Natural predators and parasitic agents and biological pathogens serve as the basis for biological methods that aim to manage pest populations. Beneficial insects such as ladybirds serve to feed on aphids and parasitic wasps serve as efficient pest controllers for specific pest species (Kwenti, 2017). Pests can be treated with infectious agents from microbial fungi or bacteria or viruses which lead to their death. The selective nature of these methods directs their effect toward pests only so natural ecosystems remain protected (Alphey & Bonsall, 2018).

IPM institutions classify chemical methods as their final option, yet these methods become essential when alternative measures fail to deliver results. Lethal and low-toxicity pesticides are employed for these situations to safeguard non-target species and the natural environment (Kwenti, 2017). The application of these chemicals occurs with precision only within threshold levels so both effectiveness and minimal usage can be maintained. IPM delivers a durable pest management system by combining various pest management techniques. The comprehensive approach provides simultaneously crop defense while promoting environmental health along with sustainable productivity of agriculture in the long run (Bashyal, Poudel, & Gautam, 2022).

3.5.1 Cultural methods

The core part of Integrated Pest Management (IPM) is represented through cultural methods which modify agricultural environments to decrease population densities. Purpose of these techniques is to modify agricultural operations which reduce environmental conditions that promote survival and reproduction of pests (Pandey, 2024). Farmers who implement these practices decrease natural pest populations while maintaining ecological agriculture (Frank, Bradley, & Moore, 2022).

Farmers widely utilize resistant crop variety selection as one of their cultural practices. Crops receiving selective breeding serve to withstand pests and diseases naturally. Plant varieties possessing natural defence properties protect crops because pests encounter obstacles that hinder their ability to eat or multiply and inflict notable damage (Ehler, 2006). The selection of resistant crop varieties helps farmers decrease pesticide usage while improving their yield production levels. The resistance of specific rice varieties in Sri Lanka protects farmers against the infestations of brown planthoppers through reliable safeguards (Pandey, 2024).

It is essential to plant crops during their proper seasons under the cultural method framework. Farmers can plan their planting period to match pest life cycles in order to minimize their populations during vulnerable times (Bashyal, Poudel, & Gautam, 2022).

The pest life cycle collapses when farmers plant crops at unusual times which results in weaker pest activity.

Growing different crops in particular patterns during multiple planting seasons makes up the essential practice known as crop rotation. Cropping different plants in sequence interrupts the ability of specialized pests to build massive populations because their preferred species becomes unavailable (Angon et al., 2023). The implemented method delivers outstanding results against pests and pathogens that reside in the soil. Hanging legume crops and alternate feedstuff like non-rice crops between paddy rotations serves pest life cycles of rice-specialist organisms which minimize their appearance in future rice growing seasons (Frank, Bradley, & Moore, 2022).

Intercropping involves sowing multiple crops in the same plot which proves to be an efficient cultural method. The introduction of different plant varieties into a single field creates pest protection because pests cannot easily devastate all the crops (Ehler, 2006). When companion plants interact with pests in specific ways, they either deter pest infestations or support beneficial natural enemies that prevent pest outbreaks from happening. Community-style farming includes the integration of flowering vegetation near crops to draw beneficial insects including parasitic wasps and ladybirds which naturally control pests. These organic cultural practices stop populations while building a sustainable farming system. The preventive approach combined with reduced dependence on external substances makes cultural practices suitable for sustainable agricultural management. Using biological approaches helps protect soil quality and lowers chemical pesticide expenses at the same time it reduces environmental degradation. (Smith & McSorley, 2009)

3.5.2 Physical/mechanical methods

Technical efficiency of integrated pest management (IPM) in controlling pests depends heavily on mechanical and physical measures that are ecologically innocuous. Such agricultural controls remain popular with small farming operations since they provide affordable and organic pest control solutions that help farmers avoid chemical fertilizers and pesticides (Zhou et al., 2024).

Barriers represent a fundamental physical approach in preventing pests from getting to crops. The physical barriers composed of insect nets mesh screens and row covers function as shields that stop pests from reaching plants (Ahmad et al., 2024). Such structures provide excellent protection against flying insects such as aphids and whiteflies but permit sunlight and air and water transmission. Producing a lightweight netting barrier for vegetable crops results in effective pest reduction which eliminates the requirement for pesticide application (Holtz et al., 2020).

Sticky traps represent a well-known mechanical pest monitoring tool that functions to maintain control over pest numbers (Gamage et al., 2023). These pest control devices contain adhesive coatings which enable the capture of flying insects including fruit flies as well as leafhoppers and moths. Specially positioned sticky traps decrease pest presence while providing a warning system that lets farmers act in time against rising pest groups. Small-scale farmers value sticky traps because these easy-to-use traps prove to be effective tools for pest control (Ahmad et al., 2024).

Application of mulch serves two functions simultaneously within pest management strategies and promotes soil quality improvement (Mergia et al., 2021). The application of organic and synthetic cover materials including straw and plastic or biodegradable films on soil surfaces functions as a protective barrier to block pests such as weeds as well as nematodes and specific insects from accessing the crop. The application of mulching enables farmers to benefit through soil temperature regulation together with improved moisture control and enhanced crop growth (Holtz et al., 2020).

Small-scale farmers typically depend on manual removal since it is both direct and labour-intensive for pest control. Method requires hands-on pest removal from plants together with leaf removal and the destruction of egg clusters located on the crops (Vuković et al., 2022). Simple human intervention works well for small crop operations, but larger operations would find this method impractical. This pest management approach provides swift population reduction especially for caterpillars and beetles and grasshoppers because all visible pests can be physically removed (Angon et al., 2023).

Physical pest control instruments developed for pests serve as a common mechanical pest control measure (Stapleton, 2020). Farmers use light traps as nocturnal insect attractors since they guide flying pests towards illumination units for trapping or destruction. Natural mating signals serve as the basis for pheromone traps that attract pests until their population decreases. The concentrated methods in pest control reduce dependence on chemical pesticides with broad spectrums while protecting beneficial insects that exist within environment (Zhou et al., 2024).

Soil solarization stands as one of the physical pest management techniques employed by farmers in their fields (Mergia et al., 2021). By using transparent plastic sheets as a cover for soil farmers can efficiently sterilize plant-based organisms such as weed seeds and nematodes and other pest forms by trapping solar heat. Soil solarization serves tropical and subtropical climates well because intensive heat conditions improve its operational power (Stapleton, 2020).

Small-scale farmers use these physical and mechanical methods which function well in conjunction with sustainable farming systems. Practice of these methods provides two major advantages by lowering pesticide-related environmental hazards and promoting better pest biology knowledge (Ahmad et al., 2024). These methods provide accessible affordable solutions that small farmers can use because of their limited resources (Mergia et al., 2021).

3.5.3 Biological methods

Methods that use biological agents serve as vital components for environmental pest management programs. Natural predators' parasiticides and pathogens function as biological pest control methods to minimize populations in an environmentally safe and non-toxic manner (Kumar et al., 2021). Natural biological control mechanisms allow farmers to seek effective pesticide alternatives that protect both the environment and agricultural growth in the long term. Natural predators serve as the essential component of biological control system implementation. The diet of these natural predators includes destructive pests which they maintain at limited numbers. Paddy cultivation relies on using ladybugs as a biological control agent against aphids. Ladybugs demonstrate exceptional efficiency when consuming aphids because these pests are destructive crop feeders that Damage plants by extracting their fluid contents. The natural occurrence of ladybugs in paddy fields tracks aphid populations below damaging levels while keeping helpful organisms unharmed (Kwenti, 2017).

Main components of biological pest control include parasiticides which function alongside other important elements. Many insects function as pests through their practice of laying their eggs both within and upon the bodies of their host pest organisms (Usta, 2013). The parasitosis-developing larvae consume the pest following egg hatching which leads to pest death. Trichogrammatid wasps operate as biological agents against caterpillar pests that cause damage to rice plants in paddy cultivation. The pest-management strategy of Trichogrammatid wasps stops caterpillar pest populations in their early stage because these wasps target eggs before they mature into damaging organisms. The method achieves specific pest control because it attacks only targeted pests rather than beneficial organisms (Jeffers & Chong, 2021).

Use of pathogens including bacteria and fungi and viruses constitutes a vital biological pest management technique because they cause infections which result in pest death (Jayasooriya & Aheeyar, 2015). Bacillus thuringiensis (Bt) serves as the major microbe used for paddy cultivation. The bacterial toxin Bt exists naturally in ecosystems and generates dangerous proteins that specifically damage moths and beetles and fly larval populations. Bt toxins cause death in pest larvae by disrupting their digestive tract functions after ingestion. The application of Bt-based formulations by farmers on paddy fields maintains pest insect control of larvae while protecting people and animals as well as beneficial insects (Kumar et al., 2021).

Along with predators and parasiticides and pathogens farmers conduct additional measures to improve natural environments which attract more biological control agents. Edges of paddy fields become beneficial habitats and food resources when farmers plant flowering plants since predatory beetles and parasitic wasps find suitable ecosystems (Mawcha et al., 2024). Habitat management serves as a conservation strategy that maintains stable populations of natural enemies, so farmers decrease their reliance on chemical controls.

Introducing fish into paddy fields represents a biological technique which is also known as rice-fish farming. Natural predators of mosquito larvae and aquatic insects that damage rice plants are certain fish species including tilapia and common carp (Usta, 2013). Rice-fish farming acts as both a pest-control strategy and produces extra revenues from fish harvesting thus establishing itself as a financially sound and lasting agricultural practice (Mawcha et al., 2024).

People who implement biological control methods need to establish proper strategies along with regular oversight for effective results. Farmer identification of targeted crop pests enables them to choose appropriate biological agents properly (Kumar et al., 2021). The success of biological agents depends significantly on correct timing since they excel at different life cycle phases of targeted pests. Pest population monitoring in conjunction with biological agent health checks enables farmers to take informed decisions that lead them to modify their pest control strategies. Biological pest control procedures provide additional advantages above pest population management efforts. These pest management strategies protect all groups from harm by removing the requirement for pesticides or significantly reducing their usage. Such practices conserve water and soil quality counter pesticide resistance and protect the natural diversity of agricultural habitats. These methods prove financially beneficial in the long run by minimizing repeated chemical usage thus promoting natural pest control (Jeffers & Chong, 2021).

3.5.4 Chemical methods

When none of the other methods of control can regulate the population of the pests, the use of chemical pest control measures is the last resort for Integrated Pest Management (IPM). The use of natural and synthetic chemicals in different forms enables the elimination of the pests and their inhibition from developing to safeguard the crops (Deguine et al., 2021). Chemical pest control methods deliver efficient results quickly, yet require careful handling, since they could harm the ecosystem and people as well as unintended organisms (Fredricks et al., 2019).

The modern agricultural sector pursues the advancement of non-harmful as well as environmentally compatible pest control substances. Botanical insecticides that derive their origins from plant extracts represent some of the newly developed biological alternatives in industry (Chaudhary et al., 2024). Three insecticide products derived from botanical sources which include Neem oil and pyrethrin and rotenone pose less danger than standard synthetic pesticides. These biodegradable natural compounds have reduced environmental dangers which prevents the accumulation of damaging crop chemicals (Gupta, Sharma, & Ramniwas, 2021).

Anthropogenic pest control techniques have been expanded through the development of microbiological pesticides (Chaudhary et al., 2024). Chemical pesticides derive from microorganisms including bacteria and fungi together with viruses to eliminate pests without injuring non-targeted organisms.

Trying to gain benefits from contemporary chemical pesticides requires precise handling due to their potential negative impact on the environment. Correct methods of chemical application guarantee efficient and safe usage (Satya Sai et al., 2019). Farmers must properly set their equipment to specifications and use pesticides only when weather permits following all prescribed quantity and use instructions to prevent toxic material leakage. Using both excessive and insufficient chemical amounts alike creates soil runoff which pollutes water ecosystems and harms aquatic organisms, but inadequate use leads to pest survival thus endangering plant life (Fredricks et al., 2019).

Appropriate resistance management techniques remain essential for maintaining sustainable utilization of chemical pest management operations. Sabotaging pests build resistance to pesticides during extended usage, so more pesticide is needed or different chemicals become essential (Matthee, 2024). The combination of different pest management techniques provides resistance prevention to farmers including pesticide rotators and necessary pesticide use limits along with integrated Pest Management approaches. Implementation of these methods prevents chemical controls from losing their effectiveness by preventing pest resistance (Jambagi et al., 2023).

The main benefit of chemical pest control arises from its instantaneous pest-elimination capability. The chemical pesticides become essential for controlling pests whenever their numbers escalate toward harmful thresholds because they ensure immediate insect reduction to save yields and safeguard food security (Sharifzadeh et al., 2018). Every farmer needs rapid pest control action when stem borers and rice hoppers appear since these pests can wipe out entire fields in only a short period (Matthee, 2024).

The advantages of chemical pest management need to be carefully considered because of possible negative impacts. Heavy use of chemical pesticides creates three major negative impacts that include the destruction of helpful insects together with water and soil pollution which leads to health risks from chemical exposure (Jambagi et al., 2023). To develop an effective sustainable pest management system, chemical weed control needs to work alongside biological and cultural IPM approaches (Gupta, Sharma, & Ramniwas, 2021).

Paddy cultivation benefits from the strategic implementation of chemical approaches for pest management because this practice helps maintain ecosystem balance. Rice insecticide application focused on the times when pests present the highest densities allowing maximum defence against pests in addition to maintaining minimal pesticide usage (Cai & Dimopoulos, 2024). Habitat management practices together with chemical methods provide a sustainable approach for decreasing pest susceptibility while lowering the need for chemical applications in the long run (Chaudhary et al., 2024).

Effective chemical pest control depends on teaching people about it as well as making them aware of its proper use. Mandatory training must be provided to farmers for proper pesticide usage together with extensive instruction about the correct handling of pesticides and protective equipment for chemical safety (Satya Sai et al., 2019). From an agricultural perspective, farmers should receive information regarding essential pre-harvest intervals to guarantee that consumed crops maintain safe chemical residue levels.

4 Research Methodology

4.1 Research method

In this study, a mixed methods approach has been adopted where not only the quantitative but also the qualitative aspect has been perceived to comprehend the interpretation and the implementation of the Integrated Pest Management (IPM) practices in paddy production in the Southern Province of Sri Lanka. The quantitative method involves the collection of several data via the means of structured questionnaires distributed to paddy farmers. This approach was used to carry out statistical analysis to identify the pattern, frequency, and relationship of IPM adoption to productivity and pest control (Saunders et al., 2019).

The other parallel qualitative method is the semi-structured interviews conducted with selected farmers, agricultural officers, and experts to capture in detail what they mean by their perceptions, experiences, and challenges regarding IPM practice. The approach facilitates analysis of more contextual factors, individual behaviours, and culture that may influence the adoption and effectiveness of IPM practice (Dawadi et al., 2021).

With the combination of both methods, one gets a more holistic view where numerical evidence and rich, narrative data are balanced. Using the mixed methods approach can increase the reliability and validity of the research findings and increase the reliability of the findings by triangulation – where the data is taken from more than one source and more than one method. As a result, this strategy ultimately helps build a more nuanced analysis and gives practical advice on ways to improve IPM adoption in the region’s paddy farming systems (Mcleod, 2024).

4.2 Research Approach

The research design for this study follows an abductive approach that entails both inductive and deductive reasoning in the integration and application of Integrated Pest Management (IPM) in paddy farming (Saunders et al., 2019). The abductive approach first looks at observations drawn from the real-world practices and problems that face farmers such as poor farm profitability, loss of soil nutrients, etc., deriving patterns and hypothesizing the generation of theories that can explain the patterns. They serve to inspire the conceptualization of a framework that is assessed and reworked using empirical research (Taherdoost, 2022).

In this research, the abductive approach allows the researcher to tackle existing theoretical perspectives on IPM at the same time as allowing for new perspectives in this field to emerge from the field (Saunders et al., 2019). For instance, there are established theories with regards to sustainable agriculture and pest control but probably due to some unique socio-economic, cultural, or environmental factors, the implementation of the IPM practices by farmers in the Southern Province of Sri Lanka may deviate from established theories. The study takes an abductive approach to the advantage of such contextual factors as that the resulting findings are theoretically reasoned yet grounded in the realities from where they are (Tenny et al., 2022).

However, this approach is particularly well suited to research on complex human behaviours and the processes of decision-making in general and is therefore ideally suited for explaining why and how farmers adopt or resist IPM practices.

4.3 Data collection

To gain a complete picture of Integrated Pest Management (IPM) practice in paddy cultivation, this study utilizes a mixed method, collecting data of both a quantitative and qualitative nature. Structured questionnaires were completed for the collection of quantitative data through closed-ended questions (62 randomly selected paddy farmers of the Southern Province of Sri Lanka). Questions were developed for information that can be measured on farmers' awareness, level of adoption, how often farmers use IPM, what type of pest control methods are used, and what they perceive as the yield improvement and pest reduction (Ahmed et al., 2024).

Qualitative data is collected through open-ended / semi-structured interviews among a subset of farmers and agricultural officers, at the same time (Hands, 2022). The interviews in this case illustrate more clearly from a motivational, experiential, challenging, and contextual viewpoint the reasons for or against the adoption or rejection of IPM practices. Participants are to tell their personal stories, their perception of the old vs. the new way to control pests, and the capability or the lack of it in training or support they received from the agricultural institutions (Saunders et al., 2019).

Data triangulation uses both closed-ended questionnaires and open-ended interviews, and this improves the richness of the findings that were obtained (Tenny et al., 2022). The data was collected in two weeks (22nd February to 4th March) and the researcher distributed the questionnaire with Sinhala translation relative to the data collection progress. This provides a mixed methodology so that the study covers the wide-ranging trends and the real reasons for the announcement of the IPM to make more informed and practical conclusions.

4.4 Population & Sampling

The sampling targets the paddy farmers as well as agricultural instructors in the Southern Province of Sri Lanka. Simple random sampling procedure was used to select one sample of 62 paddy farmers to ensure each farmer had an equal chance of participations to minimize selection biases and to facilitate generalizability of findings. For the qualitative portion, five agricultural instructors were selected who were involved in direct agricultural IPM training and farmer support. Thus, this combination affords the ability for the study to gain both across-the-board farmer perspectives and expert knowledge regarding IPM practices and their effectiveness.

4.5 Data Analysis

An analysis of adaptation and effectiveness of Integrated Pest Management (IPM) practices in paddy cultivation in Southern Province, Sri Lanka has been adopted by the researcher with a mixed method approach. Microsoft Excel is then used to analyse quantitative data obtained through closed-ended questions. The data are summarized using descriptive statistical tools like mean, standard deviation, and frequency distribution of IPM usage, pest control efficiency, and yield improvement among the selected farmers (Mcleod, 2024).

Thematic analysis is used for qualitative data obtained from open-ended questions as well as interviews. Coding the responses will then take place to identify the key themes and the recurring ideas based on the farmers' experience, attitude, and challenges with IPM practices. In this way, these themes can show reasons for adoption or resistance that are underlined and factors involved in decision-making.

The combination of these two approaches makes it possible for the study to be practical and still give away in-depth understanding while also allowing it to be informative and give away measurable insights. It supports the assertion of integration of statistical trends with the contextual narratives particularly in terms of improvement of fidelity and usefulness of the findings (Taherdoost, 2022). By so doing, it validates numerical understanding with life experiences, thereby providing more reliable and actionable recommendations for the popularization of the adoption of IPM in local paddy farming communities.

4.6 Research Ethics

The ethical consideration of this research study on paddy cultivation combined with IPM practice adaptation and effectiveness of paddy cultivation in the Southern Province of Sri Lanka is imperative. During the measurement of the research process the researcher had taken several measures to ensure the ethical standards. All participants also gave informed consent before data collection (Resnik, 2020). Each participant read and clearly understood that the study was about the purpose, and the nature of his participation, their involvement in the study is voluntary without any negative consequences. This agreement was formalized using the consent forms that we gave and signed (Dooly et al., 2017).

They were made anonymous and confidential by not bringing personal identifiers as they recorded all responses. The study also made sure that the participants were not coerced or under undue influence. Before conducting the research, relevant academic authorities were first sought for ethical approval, the study met with institutional and professional ethical guidelines. The researcher also exhibited cultural sensitivity and respect when interacting with the farming community by means, such as local customs, values, and practices (Dev, 2024). Adherence to these ethical principles will ensure that one upholds high standards of academic integrity as the research maintains one's credibility and the authenticity of the study's findings.

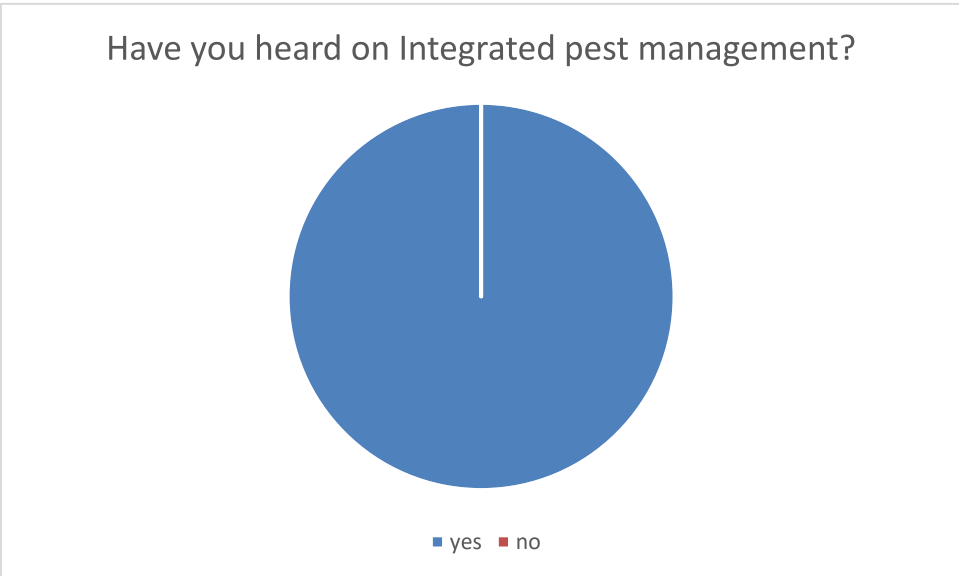
5 Finding & Analysis

5.1 Quantitative Findings

The study analysed 62 responses from farmers regarding their adoption and awareness of Integrated Pest Management (IPM) methods. The data reveals that most respondents are aware of IPM, with many reporting a decrease in chemical pesticide use after adopting IPM techniques. Additionally, most farmers reported a reduction in pest damage following IPM practices. When asked about changes in yield, many indicated an improvement, while most noted a reduction in farming costs after using IPM.

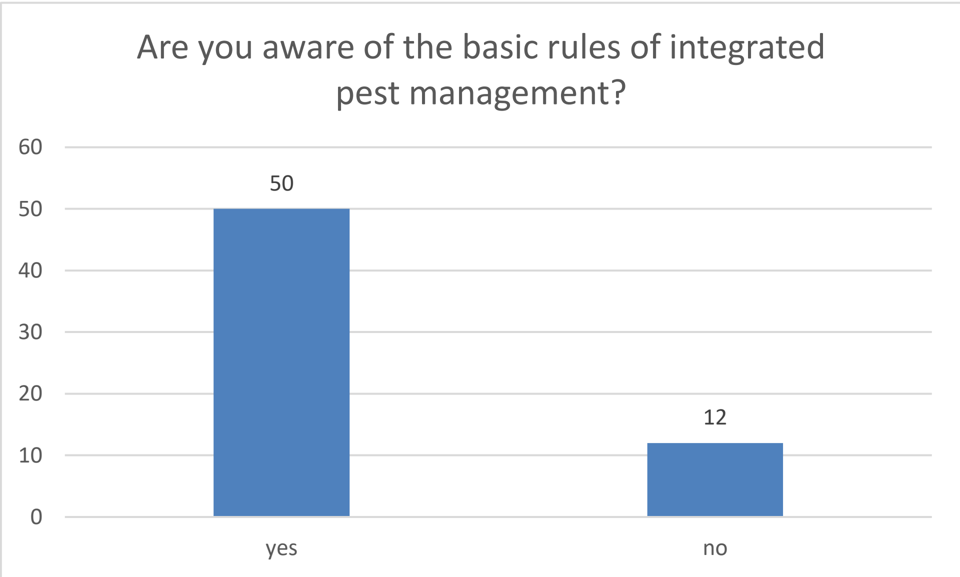
In terms of support, most respondents felt that institutional support for IPM was adequate, yet some challenges remain, such as difficulty in accessing biological control agents and a lack of sufficient machinery. Farmers expressed the need for increased awareness, financial support, and agricultural advisory assistance to further promote IPM practices. These findings highlight the positive impact of IPM on pest management, yield, and cost reduction while identifying areas for improvement in its implementation.

Figure 1. Have you heard on Integrated pest management?



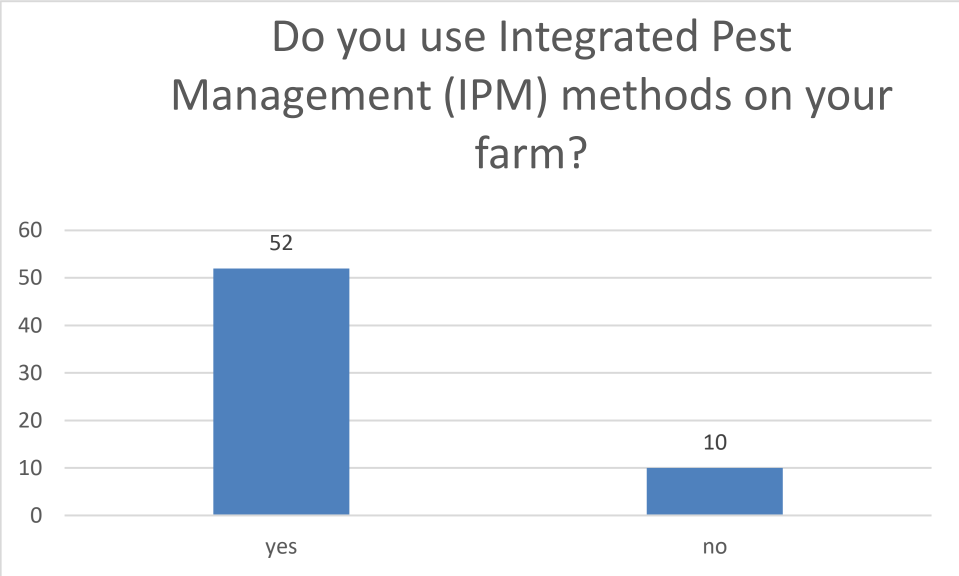
All participants (100%) have experience about integrated pest management (IPM) before. Every single one of the 62 survey participants has encountered integrated pest management (IPM). Surveyed farmers showers high awareness about IPM thus demonstrating that sustainable pest management practices are commonly recognized in their community. Every participant involved in the research demonstrated an understanding of IPM based on the 100% cumulative percentage.

Figure 2. Are you aware of the basic rules of integrated pest management?



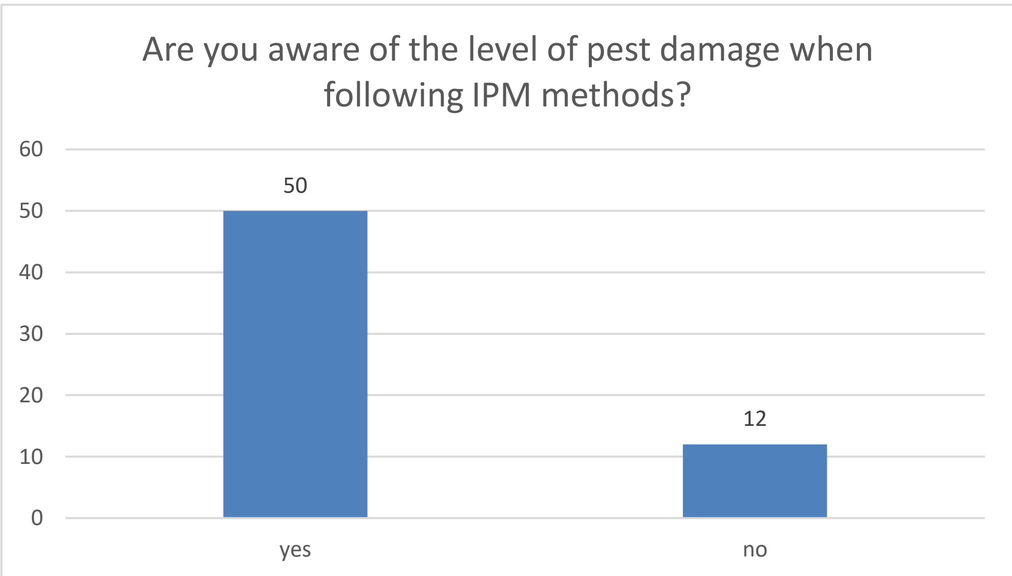
The bar chart presents respondents' awareness of the basic rules of Integrated Pest Management (IPM). Out of 62 respondents, the majority (50 respondents) indicated that they are aware of the basic rules of IPM, while 12 respondents stated that they are not aware. This suggests that while a significant portion of farmers have knowledge of IPM principles, there is still a gap in awareness that may need to be addressed through further education and training programs. Strengthening outreach efforts, particularly for the 12 respondents who lack awareness, could enhance the overall implementation of IPM practices.

Figure 3. Do you use Integrated Pest Management (IPM) methods on your farm?



The bar chart indicates the usage of Integrated Pest Management (IPM) methods among the respondents. Out of 62 farmers, 52 (83.9%) reported that they use IPM methods on their farms, while 10 (16.1%) stated that they do not. This suggests a high adoption rate of IPM practices, reflecting awareness and implementation among most farmers. However, the 10 respondents who do not use IPM methods may face barriers such as lack of knowledge, resources, or access to training. Addressing these challenges through targeted education and support programs could further improve the adoption of sustainable pest management techniques.

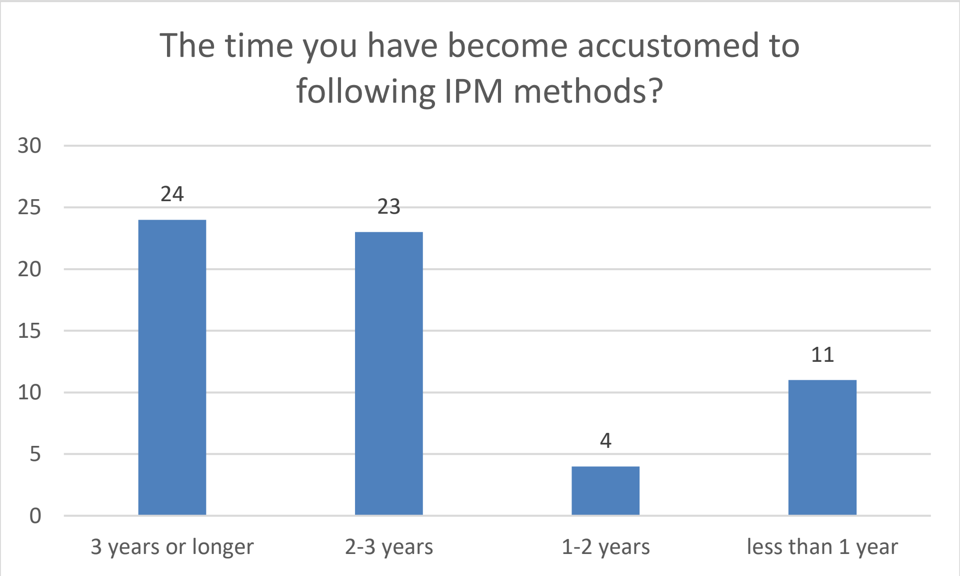
Figure 4. Are you aware of the level of pest damage when following IPM methods?



According to the data, 80.6% of farmers (50 individuals) notice pest damage levels using Integrated Pest Management methods but 19.4% (12 individuals) do not monitor it. A large proportion of farmers show active pest damage monitoring practices that support proper evaluation of Integrated Pest Management strategies.

Farmer pest control methods improve when they understand their pest damage rates because they select proper pest control measures that protect crops effectively yet reduce pesticide use. The 12 individuals representing 19.4% would gain from more training or improved resources to improve their ability to monitor pests and implement integrated pest management. The need for continuous education through extension services emerges as crucial to developing farmers' capability in performing sustainable and effective pest management strategies.

Figure 5. The time you have become accustomed to following IPM methods?

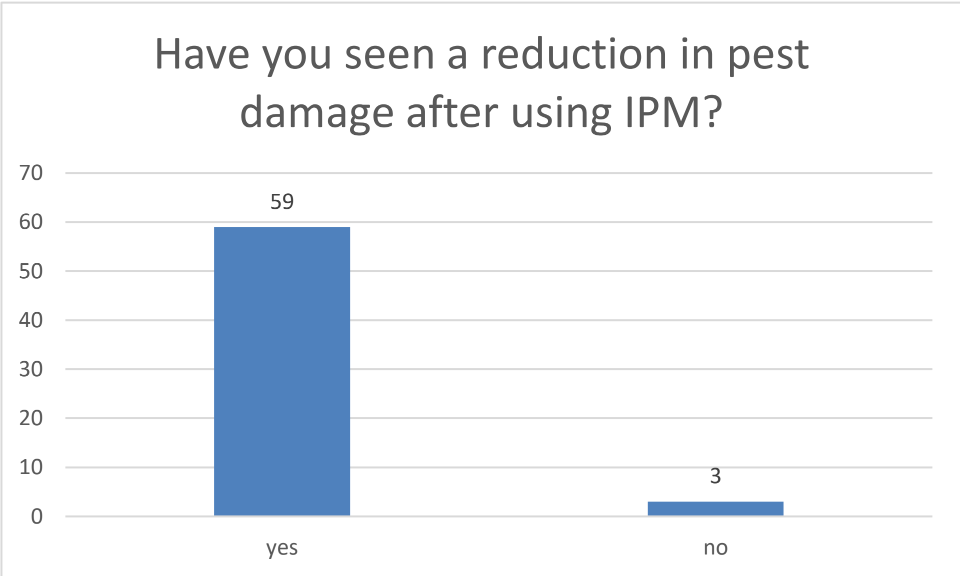


About 38.7% or 24 farmers have practiced Integrated Pest Management (IPM) for three years or longer demonstrating a strong commitment to sustainable pest control strategies. A total of 23 respondents representing 37.1% of the sample population use Integrated Pest Management (IPM) over a period of 2 to 3 years while 11 participants, involving 17.7% had

practiced IPM for less than a year. The population practicing IPM for 1 to 2 years includes only 4 farmers representing 6.5% of the total.

Long-term IPM experience among numerous farmers will aid both pest management efficiency and sustainable farming techniques. The new adoption of IPM practices remains active due to the high number of individuals (17.7%) who started within the last year. The adoption rate of Integrated Pest Management practices can be enhanced through better training methods that help experienced and new farmers exchange knowledge with one another.

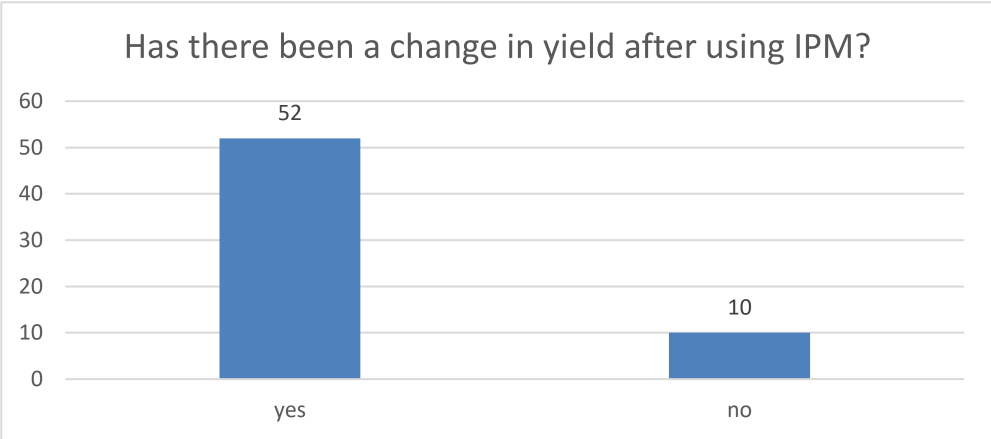
Figure 6. Have you seen a reduction in pest damage after using IPM?



Research data shows that Integrated Pest Management methods succeeded in reducing pest damage according to 59 farmers who reported a 95.2% success rate. A minimal number of participants amounting to 4.8 percent reported not seeing a decrease in pest damage within their fields.

The data shows that IPM strategies achieve a successful pest reduction which leads to increased sustainability in the agricultural sector. These findings demonstrate why it is essential to maintain education programs supported by ongoing initiatives that help farmers learn better IPM techniques. Studying the obstacles experienced by the minority of farmers who did not get positive results from IPM implementations will enable better method optimization to enhance overall outcomes for everyone.

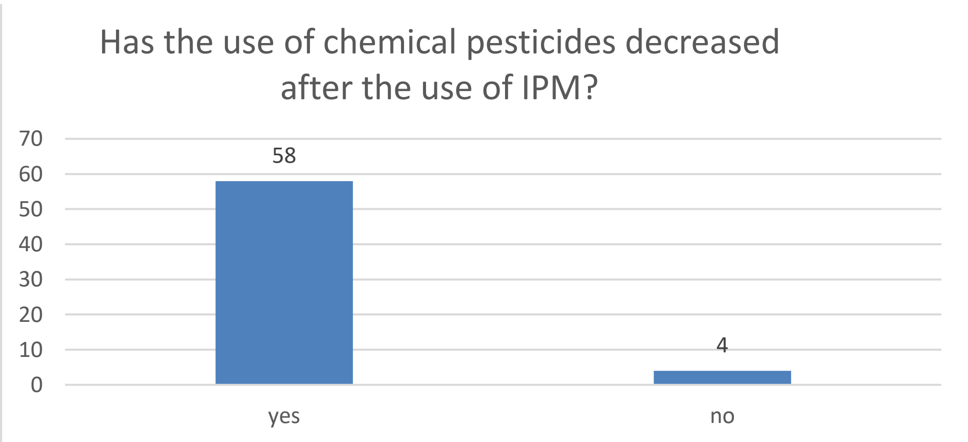
Figure 7. Has there been a change in yield after using IPM?



The data indicates that 83.9% of farmers (52 individuals) experienced an increase in yield after adopting Integrated Pest Management (IPM) methods, demonstrating the positive impact of IPM on agricultural productivity. However, 16.1% (10 individuals) reported no change in yield, suggesting that while IPM is generally effective, its success may depend on factors such as crop type, environmental conditions, or the specific IPM techniques used.

These findings highlight the importance of continued support and training for farmers to maximize the benefits of IPM. Investigating the reasons behind unchanged yields could help identify potential limitations or areas for improvement in the application of IPM strategies. Encouraging knowledge-sharing among farmers and refining pest management techniques could further enhance both pest control and crop productivity, leading to more sustainable and resilient farming practices.

Figure 8. Has the use of chemical pesticides decreased after the use of IPM?

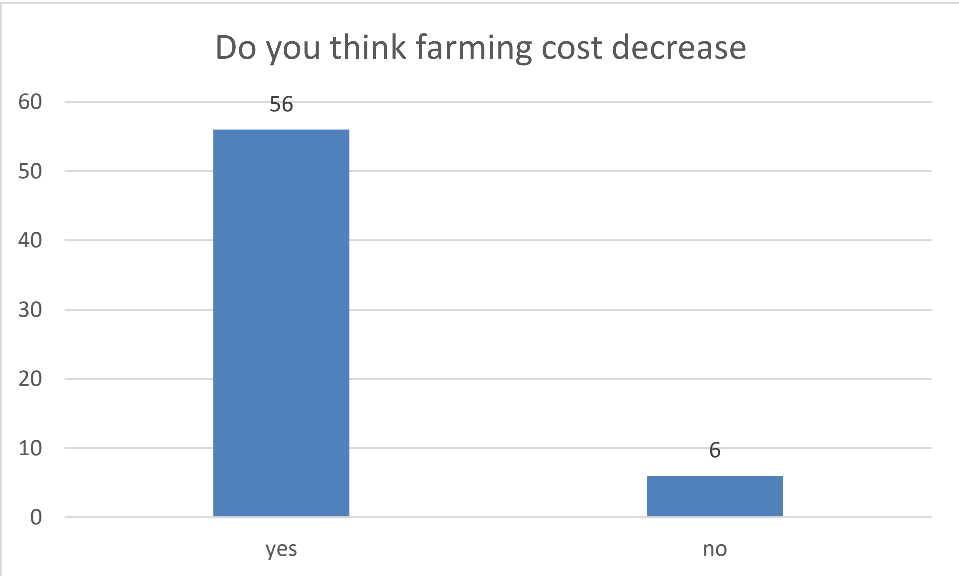


Research data reveals that farmers who used IPM methods experienced a significant reduction in chemical pesticide consumption as shown by 58 out of 62 respondents (93.5%). IPM techniques have demonstrated their ability to establish sustainable pest control methods because farmers showed a substantial reduction in chemical pesticide usage.

Unaltered chemical pesticide usage remained the same for 4 out of 4 farmers who participated in the study thus indicating missed opportunities for ecological pest control and limited adoption of proven methods including Integrated Pest Management.

Microbial biological control implementation helps agricultural producers lower both production expenses and reduce environmental and medical risks for everyone involved. The adoption of sustainable pest management strategies becomes more possible through ongoing educational initiatives for individuals who presently depend on chemical pesticides.

Figure 9. Do you think farming cost decrease?

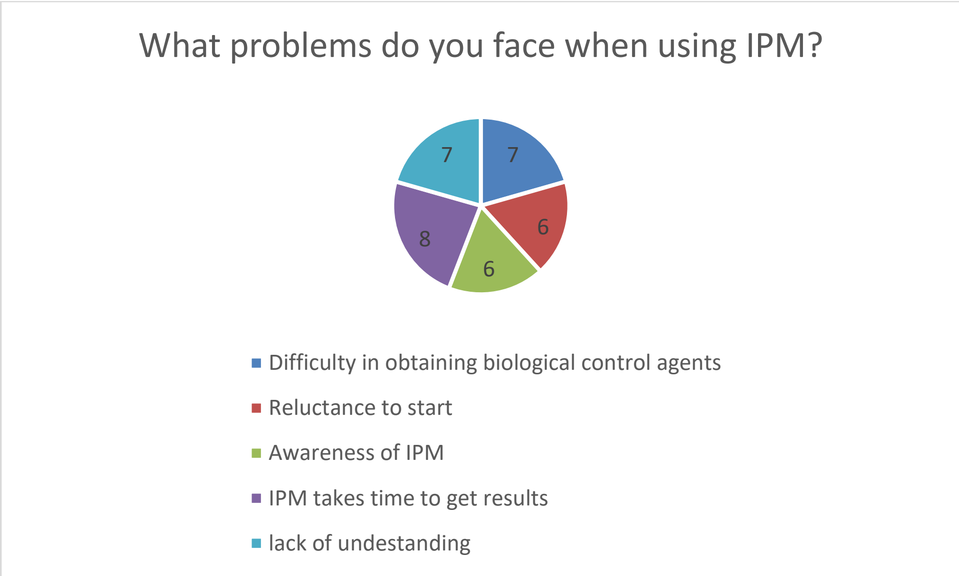


The data shows that 90.3% of farmers (56 individuals) have experienced a reduction in farming costs after using Integrated Pest Management (IPM) methods, while 9.7% (6 individuals) have not seen a decrease in costs.

This significant reduction in farming costs can be attributed to the lower use of chemical pesticides and the adoption of more sustainable pest control practices, which are often more cost-effective in the long term. By reducing dependency on expensive chemicals and relying more on biological, agronomic, and mechanical methods, farmers can save on pesticide purchases, and labour costs for pesticide applications, and minimize damage caused by pests.

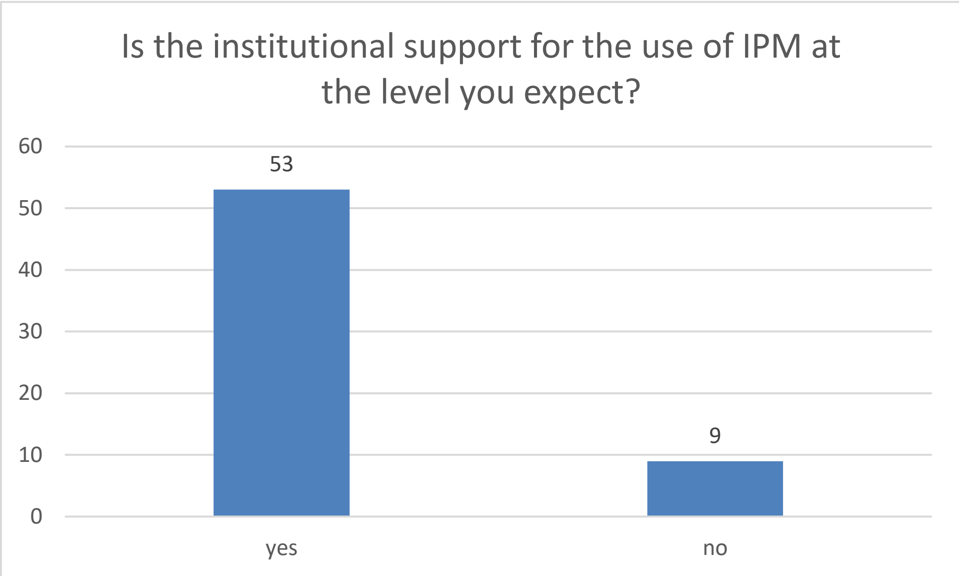
The positive impact on farming costs suggests that IPM not only enhances pest control but also improves economic efficiency, making it a sustainable option for long-term agricultural profitability.

Figure 10. What problems do you face when using IPM?



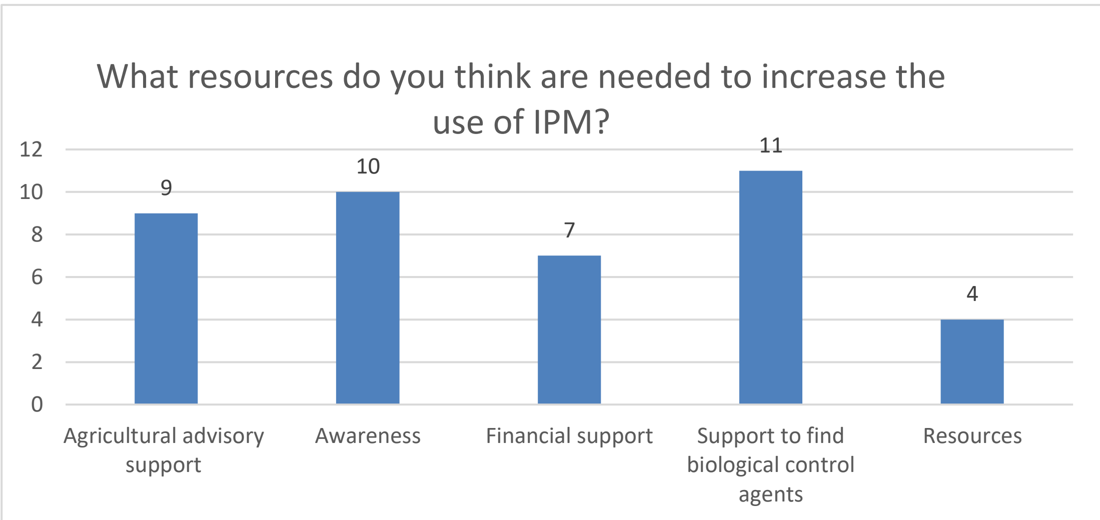
Several issues come up for farmers who attempt to implement Integrated Pest Management (IPM) methods according to data analysis. 7 farmers face problems when trying to obtain biological control agents because access to natural predators and alternative biological controls is limited. Moreover, 6 farmers see other obstacles that stop them from using IPM completely even though they understand the concept clearly. The reluctance of 6 farmers toward starting IPM programs may be attributed to their uncertainness about its success rate as well as the modifications IPM would require on their farms. During their expert interactions, 8 farmers discovered that IPM implementation demands time to create visible outcomes although this extended timetable discourages future adoption of the approach because it extends the duration needed to witness improved pest management and higher yields. Educational outreach programs need to address the low awareness of IPM as shown by the findings of 7 farmers who reported this lack of understanding. The successful implementation of IPM needs further education and support because these barriers to adoption include access to resources and both process patience and failure to grasp its significance.

Figure 11. Is the institutional support for the use of IPM at the level you expect?



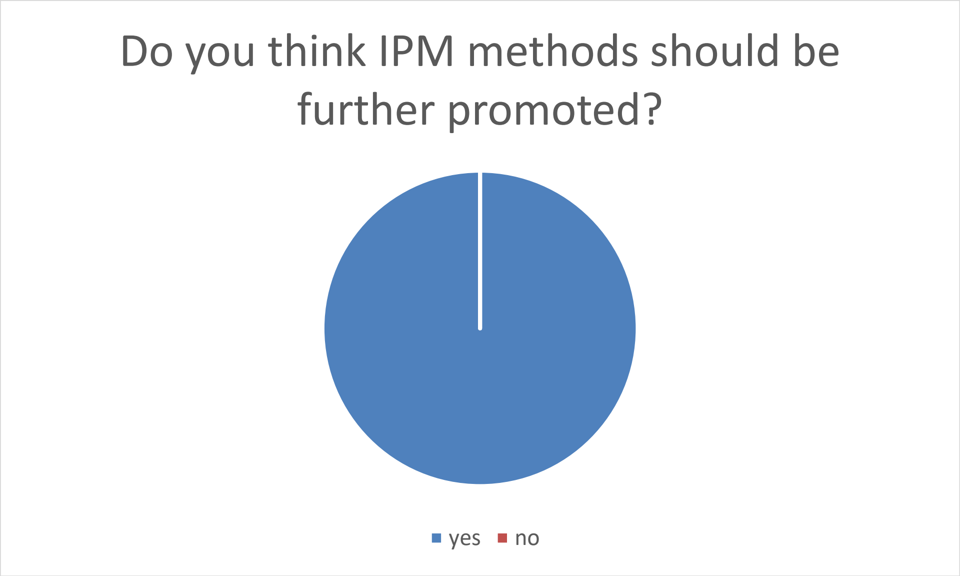
The data shows that 85.5% of farmers believe that the institutional support for the use of Integrated Pest Management (IPM) is at the level they expect, with 53 farmers expressing satisfaction. However, 14.5% of farmers, representing 9 individuals, feel that the institutional support for IPM is not at the expected level. This indicates that while most farmers are receiving adequate support, there is still a portion of the farming community that feels there could be improvements in the assistance provided to promote the use of IPM practices.

Figure 12. What resources do you think are needed to increase the use of IPM?



To increase the use of Integrated Pest Management (IPM), respondents identified several key resources. Agricultural advisory support was mentioned by 9 individuals, highlighting the need for expert guidance. Facilitating the availability of biological control agents was emphasized by 11 individuals, indicating the importance of easily accessible biological pest control options. Awareness was identified by 10 individuals, underscoring the need for greater education and information about IPM methods. Additionally, financial support was mentioned by 7 respondents, suggesting that funding is crucial to support the implementation of IPM practices. Finally, other resources were mentioned by 4 individuals, though specific details were not provided in the responses. These resources collectively reflect the need for a comprehensive approach to promote the adoption of IPM.

Figure 13. Do you think IPM methods should be further promoted?



Every participant (100%) believes Integrated Pest Management (IPM) methods need additional promotion. IPM practices find universal acceptance from all participants who advocate their increased adoption and awareness in the agricultural sector.

5.2 Qualitative Findings

The study is accountable to the qualitative findings with the open-ended questions with the collective progress on the thematic implications according to the specific theme's identifications. The 5 agricultural instructors' common options got the specific interview questions.

Theme 1: General Information

Theme 2: Awareness & Adoption Of IPM

Theme 3: Effectiveness Of IPM Practices

Theme 4: Barriers To IPM Adaptation

Theme 5: Institutional Support & Recommendations

Theme 6: Future Of IPM in The Region

5.2.1 Theme 1: General Information

The knowledge generated from the piggybacking on general information provided by the agricultural instructors is essential to providing a critical foundational gist about the professional background, experience, and the knowledge concerning pest related challenges in paddy cultivation in the Galle District. Using these responses, this evaluation synthesizes them to create a contextual framework for the rest of the analysis of Integrated Pest Management (IPM) practices.

All these five agricultural instructors interviewed had undergone formal academic training in agricultural sciences and they are fully professionals certified by the Department of Agriculture, Sri Lanka. In extension services, they act as technical assistance, training programs, field demonstration superfluent, support government led agricultural activities such as pest management and sustainable farming methods. They function as an important link to pass research-derived information on to local farmers in practical application.

They are close with farmer organizations, community-based groups, and local agricultural development officers. They conduct workshops on items, for instance seed selection, pest and ailment recognition, soil administration, and suitable application of agrochemicals. Most importantly, they also support good agricultural practices and IPM and monitor in the field how effective these initiatives are. This gives them a dual responsibility to educate and monitor so that farmers get their information and end up adopting and applying it correctly in the farming operation.

On average, the instructors have more than a decade of experience in working with paddy farmers in the Galle District, and some have been with us for more than a couple of decades. They have been immersed in extensive field experience in the region, which has provided them a highly nuanced understanding of the agricultural landscape in the region, including understanding seasons, water management issues, and outbreaks of pest and disease. At the same time, their long-standing engagement with farming communities has also helped form strong relationships, allowing a greater understanding of the social and behavioral characteristics which affect the decision-making process regarding the farming decisions.

The instructors state that their participation in the program has evolved over the years. Their current approach is now more focused on sustainability, integrated (multi)-approaches, as well as minimal environmental harm, but was first oriented more towards chemical pesticide recommendation and yield maximization. In addition, several instructors have been trained on national and provincial IPM training programs in the country, and then farmers are oriented by these instructors in Galle according to their own needs on IPM. Their long-term presence in the area has also let them to see generation farming changes. An example is that younger farmers are more encouraged to adopt new technologies and IPM while older farmers remain adhering to conventional methods, thus limiting wider adoption of IPM.

The interviews fact that the point to the occurrence of different pests throughout the Galle District, is a major subject. Unanimously, the instructors named brown planthopper as the most destructive pest that is widespread notably during the Yala season when the environment factors are favourable for its dispersal. ‘Hopper burn,’ is caused by this pest which results in severe yield losses if not managed; however, it is this pest that poses the greatest threat to cotton crops. Often, such responses by farmers result in their excessive use of chemical pesticides, leading to build-up of resistance and environmental degradation.

Other pests reported are stem borer, leaf folder and gall midge. Tillers are notorious objects of damage by stem borers and especially during the early vegetative stage. Although not as severe, leaf folders contribute to leaf damage which limits photosynthetic capability of the plant. Gall midge though more seasonal, gives gall formations that distort plant growth and reduce the panicle formation.

They also stressed that secondary pests were appearing more because chemical pesticides were too readily used. Just for example, because of the reduction of natural predators like spiders and parasitosis, some minor pests previously no longer threatening can be more problematic. Not only has the weather become more unpredictable with climate change but pest eminence patterns have been affected by pests' life cycles as well, thus complicating pest management.

In one comment, an instructor said that 'although pests have always been an integral part of paddy farming, infestations are now more erratic, requiring adaptive response.' Thus, it emphasizes the immediate necessity of pest monitoring and localized data for the implementation of IPM. The insights contained under the General Information sub theme point to the fact that agricultural instructors in the Galle District are very instrumental in guiding and supporting the paddy farmers. This experience in the field and these community ties provide the credibility and acceptance of extension messages.

By their possessing the knowledge base and practical exposure, the instructors can be the key agents in scaling up IPM practices. Nevertheless, they are also confronted by some obstacles: the opposition of the traditional farmers because they need to be replaced, a shortage of the resources required to spread the messages, and the necessity of frequent refreshing of the training to keep up to date with the increasing of the pests' dangers as well as the development of the management technologies. These insights serve as a solid basis for the subsequent theme-based evaluation of modes of adoption, effectiveness, and performance of paddy cultivation practices in the region.

5.2.2 Theme 2: Awareness & Adoption Of IPM

Responses obtained from the agricultural instructors under the theme of Awareness and Adoption of Integrated Pest Management (IPM) have important points to contribute to the present status of familiarity, knowledge, and Implementation of IPM practices among paddy farmers in the district of Galle, Sri Lanka.

The Department of Agriculture's efforts in providing training and the paddy farmer field schools as well as the sustained efforts to improve paddy farmers' awareness to IPM have resulted in the overall awareness of paddy farmers to IPM gradually increased in the recent decade. Although familiarity varies greatly among different farmer groups. More and younger farmers often are more open to new methods under IPM and particularly adopt IPM techniques, whereas the older ones rely more upon traditional chemical-based pest control methods. Most farmers, as noted by instructors cited IPM as something they've heard of, but there's little basic knowledge of what it is, what its full scope is, 'ecological basis, monitored pest techniques, cultural methods, natural predator involvement'.

When asked what they would say if asked to estimate the current level of IPM adoption among paddy farmers in the region, instructors provided different estimates of adoption, but approximately between 20–30%. This means that though interest is increasing, practice of IPM is still at a low level. Only a small proportion of farmers are using IPM strategies, which means that some farmers adopt all these elements, including resistant varieties, crop rotation, timely field sanitation, mechanical control, and biological pest control agents. For instance, farmers often adopt only one or two IPM elements, for example, reducing pesticide use or better field hygiene without using a full IPM plan.

Several barriers were identified for instructors to obtain full adoption of IPM, including training limitations, demonstration plot availability, time concerns and doubts about the immediate effect of IPM versus chemical pesticides. Additionally, the farmers' preference is influenced by aggressive marketing of chemical pesticides by the agrochemical companies, and there is a reluctance to lose good money to the efficient growth of chemical pesticides.

Most of them agreed that most of the farmers will not fully understand the long-term benefits of IPM versus chemical pesticides. While the IPM provides various environmental and economic benefits (e.g., reduced input costs, reduced environmental contamination, and conservation of beneficial insects) these benefits are seldom immediately apparent to farmers. Chemical pesticides are quick and show visible results that justify the notion that they are more effective.

Farmers 'want immediate action over pests' one instructor commented. "They don't see that IPM establishes a healthy field ecosystem over time." This highlights the need for constant farm demonstration, farming practices education and documentation of long-term benefits like improved soil health and reduced pesticide resistance.

Although paddy farmers within the Galle District are increasingly aware of IPM, adoption of this approach is relatively low in both terms of understanding of IPM, practical challenges associated with the implementation of the approach, and the attractiveness of immediate solutions offered through chemical pesticides. Extension services must invest more on field-based learning, hands on demonstration as well as on community level awareness program highlighting the practical and long term in benefit of IPM in rice cultivation.

5.2.3 Theme 3: Effectiveness Of IPM Practices

Evaluated area of IPM practice in paddy is the effectiveness to long term sustainability and value for farmers. The agricultural instructors in Galle District had provided insights that the IPM practices have a positive but gradual impact on pest control, crop yield and pesticide application.

None of the 5 agricultural instructors argued that IPM does not work, but all of them agreed that farmers who have used IPM regularly often noticed reductions in pest damage over time. It is noteworthy that IPM might not eliminate pests but reduces pest populations to below economic threshold levels. This has been done in fields where farmers have employed cultural, biological, and mechanical methods together with timely monitoring and intervention. With respect to the practices like maintaining field sanitation, using pest resistant paddy varieties and time plant, instructors reported that they have played a significant role on reducing pest infestation rates, especially down on brown planthopper and stem borer attacks.

The instructors reported that IPM farmers tend to have healthier crops and more balanced growth, when comparing yields and crop health in IPM adopting fields with fields where chemical pesticides are the only method of controlling insects. However, it is not that the short-term yield differences are usually dramatic, even so, IPM fields seem to do a better job against pest outbreaks and environmental stress. Instructors pointed out IPM users who have managed to keep their yields more stable and in the case of grain quality, better, also thanks to healthier soil conditions and lower chemical residue. But overuse of pesticides usually leads to pest resistance and resurgence and unintended damage to crops.

One notable advantage with IPM in the region is the steady decrease on the usage of chemical pesticides. The farmers who adopt IPM come to know the risks of pesticide and start applying only when necessary, or more accurately. This has helped lower input costs, less environmental contamination and, importantly, better safety for the farmer and his or her family. Nevertheless, this reduction is more apparent among the farmers who had received continual training or acted in farmer field schools. For sporadic adopters there is still a reliance on pesticides since they are uncertain, and do not have consistent guidance on how to cultivate with a minimal use of pesticides.

Often when asked by agricultural instructors as to the best IPM methods in the Galle District, the two preferred IPM methods would be those based on cultural and biological control. There are cultural practices like the right use of water, suitable time for planting, crop rotation, and field sanitation, which are cheap and widely practiced. Leaf folders and stemborers have also been successfully controlled with biological methods such as natural predators and biopesticides such as Trichogramma and Bacillus thuringiensis. Labor intensity makes mechanical methods like light traps and handpicking less used; chemical methods instead are not used as a first resort in IPM frameworks.

Overall, IPM reduced pest damage, maintained crop health and reduced dependence of pesticides by committed users in the Galle District. Improving the financial sustainability of paddy through IPM will further require increased adoption of cultural and biological control methods with appropriately increased training and support.

5.2.4 Theme 4: Barriers To IPM Adaptation

By the theme Barriers to IPM Adaptation, the responses from the agricultural instructors provide a clear understanding of the barriers which hinder the extensive adoption of the Integrated Pest Management (IPM) practices among paddy farmers in the Galle District. The proven benefits of IPM still have several practical, institutional and psychological barriers to their acceptance.

Farmers lack knowledge and understanding of IPM, the instructors say is the major impediment for its adoption. The term 'IPM' is familiar to many farmers, but they do not understand what it means to be integrated and long term. The limited knowledge on IPM often leads to confusion or incomplete application of the IPM components, thus making IPM ineffective. Also, it discourages farmers from adopting IPM methods because of preference for instantaneous outcomes with chemical pesticides that do not take long to give results. Typically, farmers expect instantaneous pest free outcomes and are discouraged when biological or cultural methods don’t satisfy immediate requirements.

The other barrier is the resistance to changing older farmers who have been applying chemical pesticides for decades. Many people are at times traditional in their mindsets with scepticism towards the newer, ecological approaches, thus they find it difficult to experiment with other unfamiliar practices.

The instructors note that while the Department of Agriculture and the local agricultural extension services conduct some training programs and workshops on IPM, there is no good coverage nor accessibility of these programs. But most of the farmers in remote or underserved areas do not have access to IPM training or post training follow up support. The only practical demonstration and field level support was not clearly enough carried out, so farmers don't really know how to use IPM in the right way. Additionally, constraints on resources such as limited access to biopesticides, natural predators, appropriate tools for monitoring or full implementation of IPM are difficult for farmers to overcome. This also makes it difficult for farmers to access accurate pest surveillance information in time for intervention.

Instructors had both positive and negative views on the impact of government policies and subsidies for promoting IPM. Although they agreed that the government has put forth some IPM related policies and have included these policies into the national agricultural extension plans, these policies are being weakly implemented at the grassroots. Funding is scarce, their subsidies are almost always on chemical inputs, not sustainable alternatives like bio-based products or training programs.

There was also a call from instructors for more practical incentives, like subsidization of IPM kits, tools for field monitoring, demonstration plots, to help farmers to make the move. While it is fragmented without consistent funding, active follow up from the local authorities and strong policy backing, promotion of IPM will be very difficult.

Based on the above, the important impediments to IPM adoption in Galle district include lack of awareness, resistance to change, absence of practical training, and non-implementation of policy. The barriers against these need to be removed using a multiprong strategy that includes greater farmer education, appropriate resource allocations, institutional support and more specific government interventions. Policy should only then be scaled up to enable sustainable pest management in paddy farming through IPM.

5.2.5 Theme 5: Institutional Support & Recommendations

The adoption and sustainability of the Integrated Pest Management (IPM) practices rely heavily on the institutional support. Through sharing of agricultural instructors' insights in Galle District, this research shows efforts made at the institutional level alongside gaps which need to be bridged for further improvement of paddy farmers' adoption of IPM.

The region has various IPM training programs based on the Department of Agriculture, Agricultural Extension offices and non-governmental organizations (NGOs). Some of these include seasonal training workshops for farmers and farmer field schools, and demonstration plots aimed at presenting and explaining other IPM approaches including pest monitoring, use of resistant varieties, biological control agents and safe pesticide application. In addition, local agricultural service centres are sometimes used alongside regional or international development agencies to deliver these training programs. The limitations, however, that instructors observed in regulating these programs were their frequency, geographic reach, and follow up support. In most situations, these sessions mostly help just a small part of the farming community, while the rest of the farming populace is derived from practical knowledge as well as practice.

However, there were several additional resources that instructors identified as needed to support broader adaptation of IPM. It was first believed that the far more educational resources; locally relevant manuals, video tutorials in the language the farmer knows, and the holding of regular community workshops, would improve the farmer’s knowledge. It also highlighted technical resources for supporting timely and effective pest management decisions such as access to pest diagnostic tools, biological control agents and mobile-based pest alert systems. Furthermore, it was also noted that financial support was a major requirement. Because alternative chemical solutions are subsidized or better marketed, many farmers will not invest in IPM methods due to initial costs. Government subsidies offered specific IPM tools and technologies, or low-interest loans will also quickly increase adoption rates.

The suggestions made by agricultural instructors to improve farmer adoption of IPM practices in the region included the following: Increase and expand farmer education and awareness campaigns.

– Increase the frequency and involvement of farmer training through training courses, mobile technology, media, etc. that can deliver IPM knowledge very strongly to farmers. Improve institutional coordination

– Facilitate assistance from government departments, research institutions and NGOs to farmers with unbiased and supportive guidance.

–Locate demonstration plots. Create localized demonstration plots in each of the important farming clusters of major villages, where farmers can witness firsthand the practical benefits of IPM.

–Offer subsidies for bio-based pest control products, IPM kits or ecofriendly tools to make the transition financially viable for farmers.

–Forging set of continuous monitoring and feedback. This will involve defining a way of continuous support and feedback of the implementation of IPM to guide the farmers to fine-tune their IPM practices and long-term adoption.

Although efforts are underway to encourage the adoption of IPM in the Galle District, institutional support evaluated and recommendations show that further education, resources and incentive-based policy-level support are necessary. Improving these areas can have a very significant impact on the adoption of IPM in the region, resulting in more sustainable and resilient paddy cultivation practices in the region.

5.2.6 Theme 6: Future Of IPM in The Region

As a forward-looking perspective, the reflections of agricultural instructors on the future of Integrated Pest Management (IPM) in the Galle District, discuss about how it may continue to be used on a wider scale and as a sustainable endeavour. But their insights are cautious optimism based on real life experience and grounded of current farm practice and institutional support system.

They all agreed that IPM has the possibility to be adopted by paddy farmers over the next 5 to 10 years, if there are constant efforts to promote awareness, prove effectiveness and institutional backing. While it took time to manifest, they saw the attitudes of farmers, especially younger ones who are more receptive to sustainable practices and the kind of eco-friendly technologies, slowly change. Also, there is increased consciousness about the adverse impact of excessive use of pesticides, which some farmers are thus turning to IPM instead. Still, the instructors cautioned that unless there were strengthened training, incentives and on the ground support the pace of adoption would remain limited. Long term education and demonstration must be provided to be able to integrate IPM into the farming culture to make it a mainstream practice.

Instructors were also asked about innovations and changes in policy to promote IPM adoption and those suggested several strategic interventions: Policy Level Recognition and Subsidies – IPM should be formally recognized and encouraged in national agricultural policy. For instance, direct subsidies or some incentive schemes for IPM tools like biopesticides, pest traps and resistant seeds could persuade the farmers to shift from the chemical methods.

Introducing mobile based applications for pest identification, weather forecasting and timely IPM recommendations could be a more user-friendly way if not the easiest especially for tech savvy farmers since it involves using a mobile phone. Expanding field school programs and including more local demonstration plots would strengthen these programs, and provide farmers with hands on learning opportunities, as well as with peer-to-peer learning networks. Collaboration with private sector stakeholders, including agro-tech companies, NGOs, and so on can be an effective way to promote IPM and tap into innovation, resources and outreach.

In their final thoughts, instructors emphasized the need to consider IPM not as a single method, but, rather, a change of mind and decent practice in sustainable and based on evidence pest management. However, they worked to clear the misconceptions that IPM is slow or ineffective by providing success stories and creating trust with farmers. The curriculum for school should include these topics and, in the youth, agricultural program to build early awareness.

The interview process was appreciated by all instructors, who found it a great avenue to share their voices, providing the stakeholders with a platform to hear what their challenges were. Ground level realities were thought to be an important part of those discussions in academic and policy terms, and therefore they believed that such interviews and research studies were necessary. An example of this kind of research is cited by another instructor as “filling in the missing gap between what we see in the field and what is talked about in offices.”

It nevertheless appears promising but on the conditions of sustained education, innovation and policy intervention for the future of IPM in the Galle District. The insights offered by the instructors present the importance of a team player and adapting to succeed in the potential of IPM to reach the sustainable agricultural development in the regions.

6 Recommendations

From agricultural instructors and evaluation of Integrated Pest Management (IPM) practices in paddy cultivation in the Southern Province of Sri Lanka, several main recommendations are made for improving awareness adoption, and maintenance for the long-term of IPM among the farmers.

1. Strengthening Farmer Education and Awareness

The lack of in-depth knowledge and understanding by farmers is one of the main barriers to adoption of IPM. Continuous educational programs in the local languages and farmer friendly formats need to be developed and rapidly delivered. The training programs for rural areas should be expanded to common regular workshops, field demonstrations, farmer field schools, hands on trainings sessions etc. Audio-visual materials and mobile based applications can help to be made more accessible and entertaining in learning. Also, including successful farmer case studies can provide motivation through peer learning.

2. Enhancing Institutional and Technical Support

IPM knowledge dissemination depends greatly on agricultural extension officers and instructors. For that reason, their capacity should be always advanced through trained training in advanced technologies and innovations in IPM. Needs to work with local agricultural offices and should be supplied with necessary tools, pest identification kits and up to date manuals. If necessary, providing a specific IPM support desk at regional agriculture centres to provide technical advice and place down on the field for farmers can help establish an IPM program.

3. Increasing Access to IPM Inputs and Resources

Thus, to encourage adoption, IPM must be supported by the willingness and means to access biopesticides, natural predators, pest monitoring tools and resistant varieties. Government support or cooperative distribution should make these resources available.

Offering subsidized IPM starter kits and kits can promote initial participation and minimize reliance on sprays (chemical pesticides).

4. Policy Support and Financial Incentives

IPM should be put formally on the national agricultural development agenda by government policies. Subsidies, tax reduction of IPM products, and grants for eco-friendly farming methods are very effective specific incentives to stimulate adoption rates. In addition, these agrochemical subsidy schemes will be reformed to include or priority sustainable alternatives, thereby guide farmers to more responsible practices.

5. Community Based and Peer Led IPM Models

Learning and support within the community may be fostered by encouraging the formation of local IPM farmer groups or clubs. Finally, these groups can share resources, exchange experiences, and collectively monitor pest outbreak. Top-down approaches are less powerful than peer led approaches of having stronger influence on local adoption, and that is supported by well trained “model farmers.”

6. Monitoring, Evaluation, and Feedback Mechanisms

An important part of continuous improvement is implementation of regular monitoring and evaluation of IPM adoption and outcomes. Depending on strategies, valuable information on pest occurrences, pesticide usage, yield changes, and farmer satisfaction will be collected. Such feedback loops between farmers, instructors and policymakers can be assured if interventions are to remain practical and relevant.

7. Encouraging Public-Private Partnerships and Innovation

IPM activities can receive support in collaboration with private sector stakeholders, agricultural research institutions, and NGOs for bringing innovation, investment and scalability to IPM initiatives. Further strengthening the IPM model can be achieved through promoting research on locally suitable biopesticides and ecological pest control solutions.

The future of IPM in the Southern Province depends upon the coordinated multi stakeholders approach centred around education, technical support, availability of resources and strong policy backing. The region can become more sustainable in terms of paddy cultivation, minimize environmental damage, and increase the farmer's resilience to possible challenges arising from pests through these recommendations.

7 Conclusion

The objective of this research was to explore the adaptation and effectiveness of Integrated Pest Management (IPM) in paddy production in the Southern Province of Sri Lanka and to do this through a comprehensive mixed methods approach. The research draws upon and combines quantitative data taken from 62 farmers and also qualitative interviews with 5 agricultural instructors to portray a holistic picture of how the IPM is perceived, practiced and sustained at the local level of the farming community.

The results indicated that farmers are fairly aware of IPM, with 100% of respondents having heard of the term. However, there is limited understanding and learning. Currently, only about 20–30% of farmers use IPM methods consistently and effectively. Most farmers use some parts of IPM methods (mechanical, cultural or any other) but few use a fully integrated approach to pest management, while chemical pesticides still dominate. This illustrates a considerable shortfall in awareness versus practical utilization mostly because of inadequate training, resource constraints, and predilection for quick results from chemical inputs.

However, the challenges seem to be overcome as the study revealed that IPM practices are having good outcomes in terms of reducing pest damage, enhancing crop health, enhancing yield and lowering costs in farming. About 90 per cent of the farmers that adopted IPM said they reduced their pest attacks and use of chemical pesticides. In addition, more than 80% experienced improved yields and this highlights that IPM has a positive effect on both environmental and economic sustainability.

These findings were supported qualitatively by the insights from agricultural instructors in relation to the challenges and opportunities concerning IPM adoption. Resistance to change is especially a barrier among older farmers, lack of access to biological inputs or pest monitoring tools and lack of government incentives or follow up support. There are efforts made by institutions, but these efforts are fragmented, lack resources and are not effectively tailored to address diverse needs of farmers.

The instructors expressed optimism that in 5–10 years this would be a much wider adoption of IPM, to young people and a more openminded farmers. But for this, the study recommends that there should be major improvement in farmer education, technical assistance, policy support and access to affordable and ecofriendly pest control alternatives.

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Appendix 1. Farmer questionnaire

Obtaining information on integrated Pest Management of Southern province of SriLanka

(All this information is used for education purposes only)

PERSONAL INFORMATION

1.Agriculure extension division……………………………………………………………

2. Age

Under 25 years
26-40 years
41-60 years
Over 61 years

3. Gender

Female
Male

4.Level of education

Primary education only
Secondary education only
Up to higher education

5.Cultivated area (acres)…………………………………………………………………

6.Period of farming(years)…………………………………………………………………

AWARENESS OF INTERGRATED PEST MANAGEMENT

7. Ever heard of Integrated Pest Management (IPM)

Yes /No

(Answer the following questions only if the answer to number 7 'YES')

8. How is that?

By Agricultural extension officers
Training programs conducted by institutions other than DOA
(Institute………………………………………………………)
Print media/ magazine
Radio programs
Television programs
From traditional knowledge (from father to son……………………..)
By farmers
Other…………………………………………….

9. Are you aware of the basic rules of IPM?

Yes/No

USE OF INTERGRATED PEST MANAGEMENT

10. do you use IPM methods in your farm?

Yes/No

11. If yes, what are the methods?

Mechanical method (crop rotation, intercropping, cultivate correct time…….)
Cultural methods (sticky traps, mulching, insect netting, manual removing………….)
Biological methods (natural predators, parasites, pathogens……………)
Chemical methods (use of chemical pesticides)
Other methods…………………………….

12.IPM methods were used to control which pests?

Cutworm
Leaf-Eating Caterpillar
Thrips
Rice Gall Midge / Rice Hispa
Aphids

Rodent Control (Mice/Rats)
Bird Damage

13. What methods did you follow in the field to repel insects?
    Use of sounds
    Trap crops
    Repellent crops
    Use of Odors
    Use of light
    Manual removing
    Baiting traps
    Use of non-chemical insecticides (papaya seeds………………….)
    Use of sticky traps
14. Awareness of harmful level of pests while adopting IPM methods
    Yes/No
15. The length of time you have been practicing IPM practices
    1 year less
    Between 1-2 years
    Between 2-3 years
    More than 3 years

PRACTICLE APPLICATION OF IPM

16. Has a reduction in pest damage been observed after using IPM?
    Yes/No
17.Has there been a change in yield after using IPM
    Yes/No
18.Has the use of chemical pesticides decreased after the use of IPM?
    Yes/No
19.Are you aware of its colour scheme when using chemical pesticides
    Yes/No
20. Is there a reduction in the cost of farming after using IPM?
    Yes/No

CHANGERS AND BARRIERS OF IPM PRACTICE

21. What problems do you face in using IPM?
    Lack of awareness about IPM
    Difficulty in obtaining biological control agents
    Awareness of IPM, but reluctance to initiate
    IPM takes time to get results

22. Is the institutional support received for the use of IPM up to the level you expect?
    Yes/No

If there is answer for No.22 'NO', what are the reasons
………

23.What resources do you think are needed to promote the use of IPM?
    Training class
    Support of Agriculture instructor
    Financial support
    Support to find biological control agents
    Other………………………

24. Do you think IPM methods should be popularized further?
    Yes/No

25.What suggestions would you make to further popularize IPM?

Appendix 2. Agriculture Instructor Interviews

Agriculture Instructors interview questions

GENERAL INFORMATION

1. As an Agriculture instructor, briefly introduce yourself and your role in extension service?
2. How long have you been working with paddy farmers in Galle district?
3. What are the main pest problems faced by paddy farmers in the Galle district?

AWERENESS & ADOPTION OF IPM

4. In your region paddy cultivated farmers how familiar with IPM practices?
5. Can you tell me, what is the estimate percentage is the current level of adaptation of IPM among the paddy farmers?
6. Do you think farmers understand about the benefits of IPM practices when compare with chemical pesticide use?

EFFECTIVENESS OF IPM PRACTICES

7. Have you observed decrease in pest damagers in paddy cultivation field, after using IPM methods?
8. What do you think about the yield change and crop health in IPM adopting farmers yield with pesticide users?
9. Do you think farmers reduced the pesticide usage after they use IPM?
10. In your region what is the most effective IPM method? (biological, cultural, mechanical, chemical)

BARRIERS TO IPM ADOPTATION

11. From your experiences, what is the main barrier for farmers hesitate to adopt IPM practices?
12. Do you think in your region farmers get good training & resources to implement IPM practices successfully?
13. Do you think how far government policies or subsidies support IPM adoption in effectively?

INSTITUTIONAL SUPPORT & RECOMMENDATIONS

14. In your region, what kind of IPM training programs have been conducted for paddy farmers?
15. Do you think what kind of additional resources (financial, educational, technical) necessary to IPM adaptation?
16. Can you tell me what are your recommendations to improve farmers adoption of IPM?

FUTURE OF IPM IN THE REGION

17. In next 5-10 years, do you think IPM becoming more accepted among the farmers?
18. Do you think, what innovations or policy changers better for adoption IPM among the farmers in your region?
19. I give time for you, if you have to say something about IPM?
20. What do you think about this interview?