Impact of CS-IPM on Key Social Welfare Aspects of Smallholder Farmers' Livelihoods

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Abstract: All stakeholders, especially households that depend on agriculture, must come up with every avenue available to improve farm productivity in order to raise yields due to the constraints posed by climate change on food production systems. Sufficient increments in yields will address the challenges of food insecurity and malnutrition among vulnerable households, especially smallholder ones. Yield increases can be achieved sustainably through the deployment of various Climate Smart Integrated Pest Management (CS-IPM) practices, including good agronomic practices. Therefore, CS-IPM practices could be essential in ensuring better household welfare, including food security and nutrition. With such impact empirically documented, appropriate policy guidance can be realized in favor of CS-IPM practices at scale, thus helping to achieve sustainable food security and food systems. However, to this end, there is yet limited evidence on the real impact of CS-IPM practices on the various core social welfare household parameters, for instance, food security, household incomes, gender roles, and nutrition, among others. We contribute to this body of literature in this paper by reviewing various empirical evidence that analyzes the impact of respective CS-IPM practices on key social welfare aspects of smallholder farm households in developing countries around the world. The review finds that CS-IPM practices do increase households' adaptation to climate change, thus enhancing soil and crop productivity, thereby ensuring food and nutrition security, as well as increasing market participation of CS-IPM adopters, thus leading to increased household incomes, asset accumulation, and subsequently better household food and nutrition security via direct own-farm produce consumption and market purchases using income. CS-IPM practices also enhance access to climate-related information, reduce greenhouse gas emissions, conserve biodiversity, and enhance dietary diversity through improved crop and livestock varieties and also reduce variable farm production costs. Therefore, there would be multiple welfare gains if CS-IPM practices were scaled up.

Keywords: climate-smart; integrated pests management; household welfare; food security

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1. Introduction

The survival of the world's population, which will reach nearly 10 billion people by 2050, depends on agriculture [1,2]. Therefore, in order to improve livelihoods, scientists believe that agriculture practiced in a sustainable manner can ensure global food systems sustainably [1,3,4]. Other scholars [5–7] argued that, sustainable food production involves producing food in a way that minimizes environmental harm while maximizing social and economic benefits and improving the welfare of Smallholder farmers' livelihoods. Smallholder farmers are often at the forefront of the improvement of food production stakes. However, they face a range of issues, including limited access to resources, a lack of appropriate practices to be used to handle climate change concerns, and pest management challenges, which are detrimental to the ecosystem [8]. These challenges lead to more frequent and severe weather events, such as droughts, floods, and storms. These events may have a significant impact on crop yields and the livelihoods of smallholder farmers. In addition to the direct impacts of climate change on food production systems, invasive pests, diseases, and weeds are wreaking havoc on many agricultural regions throughout the world [9]. This has highly caused damage to their welfare by affecting farm (crop and livestock) yields and limiting the quality and quantity of diet produced, and lifting down the food system, mainly in developing countries [8,10–12].

Literally, to achieve sustainable food systems [10,13–16], some practices have been considered by the Food and Agriculture Organization of the United Nations (FAO-UN) as Climate-Smart Integrating Pest management (CS-IPM) practices in agriculture [17]. They include crop rotation, live barriers with hedgerows, conservation tillage with mulch, contour ditches, heat and water stress, growing pest- and disease-tolerant varieties, water reservoirs/ponds with drip irrigation, insect avoidance, and establishing natural barriers, boosting the soil's ability to store organic carbon, agroforestry, and organic farming [18]. Hence, these practices appear to be an unavoidable alternative and useful to curb the adverse impact of global climate change, which has severely depleted the food resources of nearly 500 million smallholder farmers, mostly from sub-Sahara Africa (SSA), and in other developing countries [15,19,20]. Evidence shows that implementing these CS-IPM practices can help preserve soil health, reduce water use, conserve resources and promote diversity in the agricultural landscape, minimize synthetic input such as fertilizers and pesticides, and reduce tillage. Currently, the Sustainable Development Goals of the United Nations is a universal call to action (UN-SDGs) by uplifting livelihoods through food security and poverty eradication and ensuring sustainable economic growth and livelihoods as well as preservation of the environment [21].

Whenever possible, CSPM takes both adaptation and mitigation measures into account. For instance, proactive measures such as insect avoidance, such as mulching, minimal tillage, and establishing natural barriers, boost both the soil's ability to store organic carbon and the pests' resistance to it. CS-IPM practices can have several other positive direct and indirect effects on other basic welfare needs such as nutrition, household incomes, gender roles, and reducing greenhouse gas emissions (GHG) [22,23]. Such evidence is, however, scantly documented. In addition, one of the most pressing issues persisting in climate change and integrating pest management in the body of literature is the gap between climate-smart integrated pest management and key social welfare aspects of farmer's livelihoods [3,8,24]. It's in such context that scholars [8,24,25] attested that if the gap is well packaged and availed appropriately, policymakers could help scale up the use of CS-IPM practices, thus achieving impact at scale [3,26]. This study contributes to closing this gap in the literature by using meta-analysis literature review methods to examine, summarize, and report how respective CS-IPM practices have been found to impact key social welfare aspects of smallholder livelihoods.

Indeed, assessment of the impact of respective CS-IPM practices is novel, especially for regions such as SSA and developing countries where the rural poor's livelihoods are so much dependent on Climate-sensitive rain-fed agriculture [16,27]. This knowledge will be useful in guiding policy towards more prioritization of CS-IPM policies and subsequent scaling at the policy level, thus helping to establish sustainable food systems. The rest of the paper is organized as follows—next, we present the methodology used to review literature, followed by highlights of available evidence on the impact of CS-IPM practices on the welfare of smallholder households, while we discuss these highlights concurrently, and then conclude with plausible policy recommendations.

2. Theoretical Statement

2.1. Definition of Welfare

Welfare includes both positive and negative life assessments, work and livelihood satisfaction, and emotional reactions to life events, such as joy and sadness [11]. Good and bad life assessments background, job and livelihood satisfaction, and emotional responses to life events, such as joy and sadness, are all components of welfare. It also refers to how life should be lived, among other often-used meanings [11,28–30]. As a result, we distinguish between four different categories of welfare: individual, family, community, and societal welfare. Occupational and economic well-being experiences, as well as subjective physical, mental, emotional, and spiritual experiences, are all different types of individual welfare. These experiences are further conditioned by the overall organizational conditions and concrete, observable, and quantifiable circumstances of an individual's life [22,25]. The quality of interpersonal and intergenerational relationships, the family's access to resources, including financial and other resources, the environment in which people live, and the trajectory of people's development from infancy to adulthood are all part of family welfare [12,31]. Public welfare community welfare and its definitions vary, but they refer to the social, cultural, and psychological requirements of individuals, their families, and communities. Beyond only subjective welfare, it acknowledges the effects of health, poverty, transportation, economic activity, as well as environmental and ecological variables. Social, psychological, moral, and bodily welfare can frequently be found through identification with and participation in regions and communities. In line with CSPM, the core of this concept is the connection between family, the environment, and community well-being according to the good impact of different climate-smart pest management practices on their livelihood, such as food security and reduction gas emission [12,32]. People and families can exhibit higher levels of welfare and social capital when they live in low-poverty, food-secure, clean-environment, or revitalizing communities and participate in productive relationships with their neighbors and networks of friends.

2.2. Climate-Smart Agriculture Integrated Pest Management (CS-IPM) Impact on Key Social Welfare Aspects of Small-Holder Farmers' Livelihoods

Climate change is already having significant direct and indirect impacts on agriculture, including the proliferation of crop pests, pathogenic and animal species, and biotypes that are harmful to plant products. Up to 40% of all food pests in the world currently put supply at risk, and reducing pest impact is more important than ever for guaranteeing global food security and lowering greenhouse gas emissions, and decreasing input application as well [3,6]. To alleviate climate change impacts on agriculture, the Food and Agriculture Organization (FAO) of the United Nations introduced the idea of climate-smart agriculture (CSA) in 2009 to highlight the connections between achieving food security and combating the disease effect of climate change in agricultural [26,33] by emphasis the necessity of Climate Smart Integrating Pest Management (IPM) approach. CS-IPM is a multi-sectoral strategy aimed at reducing crop losses caused by pests, improving ecosystem services, reducing the level of greenhouse gas emissions per unit of food produced, and enhancing resilience and household welfare. For CS-IPM to be effective [3,6,22,25,34–36] proposed that it should not be considered as a stand-alone strategy but rather as an essential component of a broader climate-smart agriculture (CSA) initiative.

Therefore, it can be inferred from the definitions of the Climate Smart Agriculture idea that conventional agriculture cannot sustainably feed the world's population due to environmental pollution and resource depletion. Even traditional farming and food insecurity have been connected in academic studies. Conventional agriculture is, therefore, one of the main sources of emissions and minimization of forests [13]. The effect of climate change is more in temperate insects, which affects their range expansion, host enemy synchrony, and interspecific competition. However, the CS-IPM technique takes into account elements related to space, time, and the environment [6,25,26]. In addition, provide farmers with the knowledge and resources available to quickly and proactively introduce pest prevention practices [37,38]: crop diversification, construction of natural habitats and careful management of water, pest prevention practices, such as the use of pest-resistant varieties, careful selection of planting, pruning. Additionally, crop variety, conservation agriculture, push-pull approaches, integrated soil fertility, and site-specific nutrient management, as well as times of harvest, are all important [6,7,24,39].

As illustrated in Figure 1, smallholder farmers can use CS-IPM to rapidly and diligently decide on the best reactive pest control method when pest populations do reach levels that cause economic damage. By doing so, they can lessen their farms' vulnerability to pest-related disruption and the ecosystem around them. In addition, increasing crop diversity by intercropping is an easy and efficient activity and provides benefits in reducing the density and severity of the disease and pest population [13,14,39], ensuring that the management of pests and resistant varieties are ready to either avoid or resist pests coming into a region and control certain populations that are rising in numbers. In light of the severe threat posed by climate change, crop rotation, and diversification do maximize the efficient use of land, labor, and water resources, assuring food and nutrition security as well as the welfare of smallholder households.

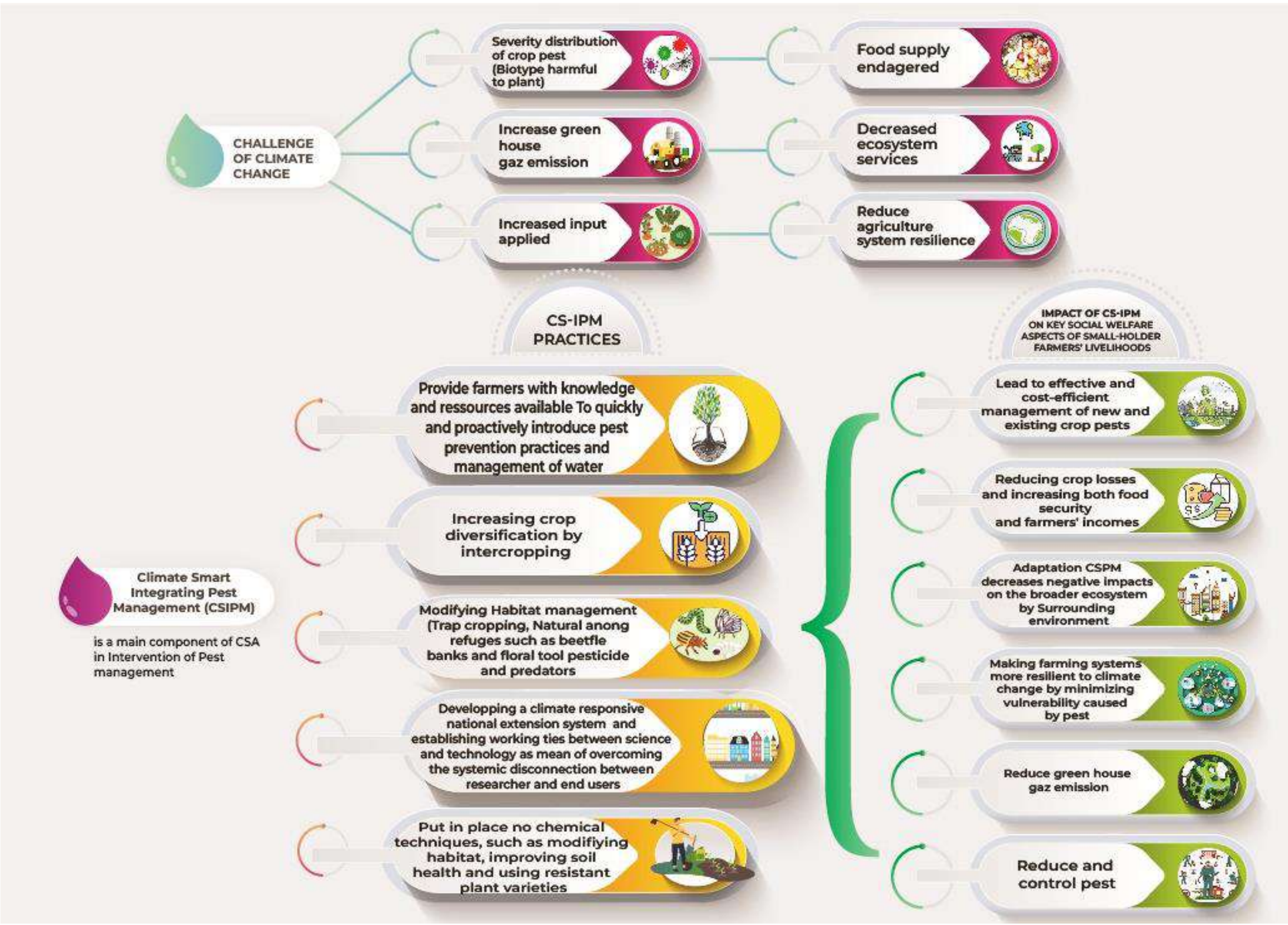

Figure 1. The author's conceptual model on the impact of Climate-Smart Integrating Pest Management (CSPM) on Social Welfare Aspects of smallholder Farmers' Livelihoods welfare. Inspired by [5,6,24,36,39] studies.

Thus, this study conforms to the Theory of Reasoned Pursuit of Goals (TRGP) of Ajzen and Guglanski [40] in such a way that it applies Climate Smart Integrated Pest Management (CS-IPM). In addition, the motivation to engage in a certain type of farming activity is largely influenced by the perception of the possibility that using farming expertise would result in success in achieving agri-food development goals [40,41]. Literally, smallholder farmers might be motivated when the choice may have positive social, environmental, and welfare effects to being entities profit maximizing [9,14,19,21]. CSPM fosters organized research, extension, and financial support and suggests techniques and approaches. Farmers cannot make judgments about proactive and reactive pest management on their own; instead, extension agencies, other research institutes, and public and commercial agencies assist farmers in making decisions by helping them choose from a variety of solutions and by providing the resources they need by creating a climate-responsive national extension system (Figure 1) and forging collaborative relationships between scientists, engineers, and farmers [42]. The CSPM seeks to reduce the structural disconnect between research and end-users, boost the resilience of farmers, and enhance small households' welfare [5,43]. Therefore, it is important to ensure that extension agencies' services are appropriate and available to all farmers, particularly those who are commonly underserved, such as women, the elderly, and people from racial or ethnic minorities.

3. Methodology and Data

3.1. Methodology

We used the meta-analysis data review approach called the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)", elaborated by Moher et al. [44] and Page et al. [45] that is rigorous, inclusive, and gives allowance to widen ones search for comprehensive information access. It is transparent and reproductive, as it does not limit our search area. Such a scoping review methodology aims to address the very reason for writing a review paper by using comprehensive, structured means to identify research gaps, provide accurate answers to research questions, and support evidence-based policy-making [46–48]. The review is based on information from peer-reviewed, English-language journals, further informed by Rosenstock et al. [46], with searches using terms relevant to CS-IPM practices and outcomes with a focus on empirical work that is inclusive of populations of smallholder farmers and how their social welfare has been impacted by key CS-IPM practices over the world.

3.2. Identification of Relevant Studies, Their Selection, and Data

The search was based on employing electronic databases, notably Web of Science (WoS), Google Scholar (GS), and Scopus tribute counts, to gather and locate published material pertinent to the topic. Therefore, in this study, Google Scholar was the major database used for such an expansive search because it contains a lot of updated work that is reflective of the research conducted in the recent past, not going beyond the year 1999. Then Wos and Scopus. GS enabled the search team to access and study several empirical studies on the impact of CS-IPM on the key social welfare aspects. According to the study of [49], there are no recent or systematic data on the variations among Google Scholar (GS), Web of Science (WoS), and Scopus tribute counts, even though researchers frequently check them and occasionally use them in study evaluations. In response, the project of [22] checks highly English citations in GS, comparing GS, WoS Core Collection, and Scopus. GS consistently found the highest percentage of citations in all subject areas (96%), far ahead of Scopus (77%) and WoS (73%). In addition, Wos and Scopus provide various research metrics such as h-index, impact factor, and citation counts [50,51]. The latter two databases offer the largest and most complete citation currently available, containing a huge array of academic literature from different sources that include pest management approaches.

The identification process of relevant articles was based on searching relevant keywords, titles, and phrases like; "social welfare", "impact of CS-IPM", "smallholder farmer households", "food security", "nutrition", "household income", and other closely related terms. Therefore, by skimming through the first 50 articles after the first 30, the rest were irrelevant. The results of the search provide 158 (95 from Google search in Google Scholar and 63 from another internet search, WoS and Scopus) relevant articles. Out of these, 61 articles were selected using the criteria of thoroughly reviewing all possible original studies that empirically had a sound and comprehensive focus on CS-IPM impact on the social welfare of smallholder farmer households. In order to understand the influence that various CS-IPMs have on the many basic social welfare characteristics of smallholder farmer households, this study gathered variables. This methodology has also been widely used in recent empirical meta-analysis review studies [22,47,48,52,53]. In Figure 2 below, we diagrammatically elaborate on the reviewed relevant studies and the final selection of the 61 articles considered for this review. The result from these relevant articles are presented and discussed in Section 4.

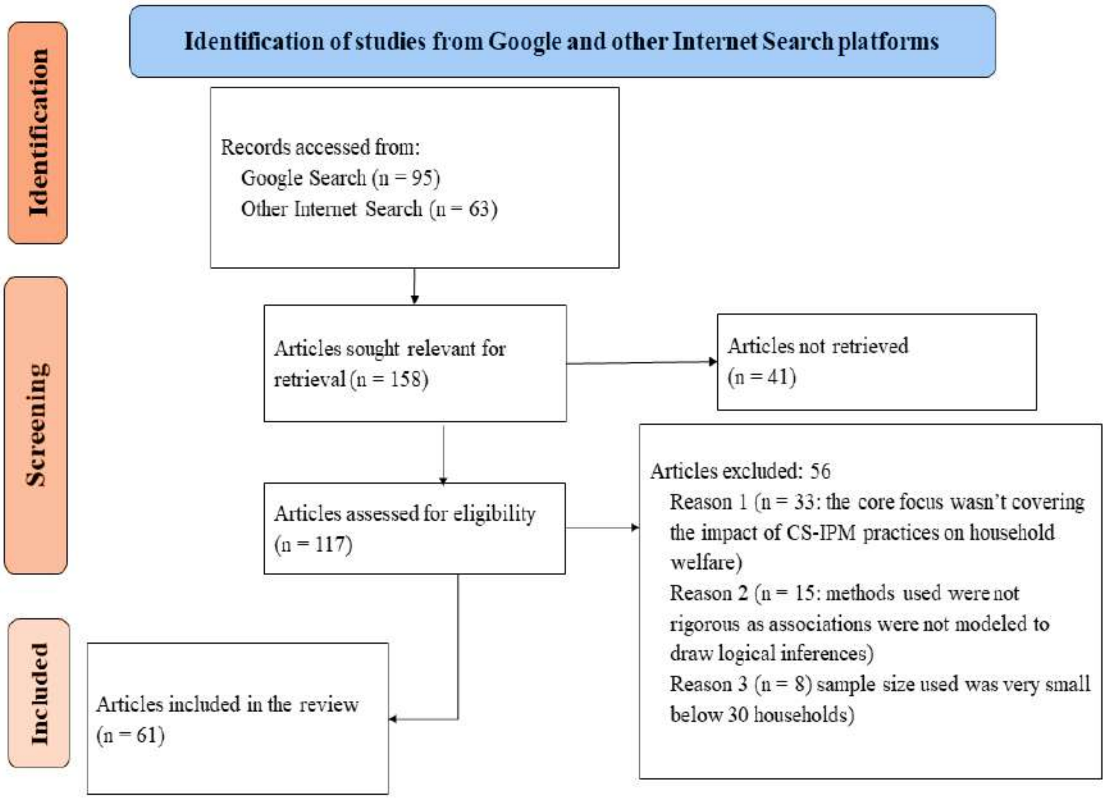

Figure 2. Methodology to identify and select articles for the review.

4. Results on the Impact of CS-IPM Practices on Key Small Holder Households' Social Welfare Aspects

One of the crucial paths to enhancing the well-being of smallholder farming communities, especially in developing nations, is through the adoption of CS-IPM [54]. This is because CS-IPM does help farmers to meet their increasingly growing demand for food via improved agricultural productivity, thus attaining food security, economic development, and poverty reduction [14,53,55]. CS-IPM practices help conserve the natural capital, especially land, more so the soil organic matter [14,56]. This also translates into higher soil fertility and structure, which will enhance plant nutrition, boost water retention, and improve soil structure. In theory, this will increase yields and strengthen the food system, improving food security and the welfare of small farmers [1,52]. The results of this study are presented by sub-themes to provide a better understanding of the research outcomes.

4.1. CS-IPM Knowledge Pest Preventions and Water Management Practices Impact on Key Smallholder Households' Social Welfare Aspects

The sharp fall in the oil prices the world over rendered oil-producing countries, such as Trinidad and Tobago, vulnerable to economic shocks. Therefore, the alternative turned out to be agriculture tailored with the use of CS-IPM practices to ensure productivity as well as align with changes in the climate. Indeed Bissessar et al. [57] have described the Caribbean region as one whose food security and nutrition are devastatingly affected by climate change, citing the region's use of outdated methods of food production, among others, for a long period of time. Many farmers and field officers received extensive training in sustainable CS-IPM to support and ensure that wholesome and nutrient-dense food is produced and made available to customers. These trainings promoted non-chemical pest control, reduced the use of conventional farming methods and chemical fertilizers, and adopted other sustainable practices on the farm [32,58]. These CS-IPM initiatives, together with farmers' indigenous knowledge, help bring benefits to the agricultural sector and improve agronomic practices that lead to reduced crop losses and increased yields.

Additionally, it was found that the majority of farmers in West Africa and Iraq [32] employ the contour stone bunds technique on their fields to prevent runoff and erosion [14]. The scaling up and extending of this CS-IPM practice among farmers, coupled with biological measures and the use of organic fertilizers and mulching, optimized water, and nutrients used in plants, thus boosting crop production, and inducing economic benefits for the poor resource smallholder farmers [59,60]. Bunds also aid in the growth of vegetation because they trap grass and shrub seeds, preserving plant diversification and increasing the food and wood fuel available to smallholder farmers. The bunds have indeed, in countries such as Niger and the Central Plateau of Burkina Faso, not only helped to increase yields for cereals such as sorghum but also have [61] fostered the increase in groundwater levels that have helped farmers start growing vegetables on small plots nearer to water sources such as wells—leading to improvement in both their incomes and diversified diets [54], while as well reducing GHG emissions [4,32].

According to Liboster's assessment of the gendered perspective of changes in pest prevalence and management in Zimbabwe, farmers' perceptions of these changes vary by gender [61]. Gender perception of change in the prevalence of pests can be a valuable resource for the sustainable development of smallholder irrigation farming systems and scientific research [9]. Therefore, CS–IPM practices in Zimbabwe have been found to register both direct gains in improved crop and livestock productivity and reduced total variable costs [62], as well as indirect gains in improved food security through the increased availability of staple crops at household level and in markets [63]. In addition, increased household income [64] and increased demand for farm labor, which brings about better wages for smallholder farmers [64].

4.2. CS-IPM Modifying Habitat Management Crop Diversification and Rotation Practices Affect Key Smallholder Households' Social Welfare Aspects

To constrain FAW pests and stem borers, smallholder farmers in Rwanda and other sub-Saharan African nations such as Uganda, Kenya, Ethiopia, and Zimbabwe have utilized numerous techniques [61,65,66]. These include handpicking, using plant extracts, combining soil, ash, and sawdust with pepper, intercropping, and spraying pesticides. The continued use of pesticides has led to pest resistance and has negative effects on humans, animals, and the environment. Striga, stem borer, and fall armyworm are just a few examples of the parasite pests and weeds that have severely restricted Kenya's ability to produce maize. The government of Kenya and its partners have developed, disseminated, and promoted the continual uptake of integrated pest management technologies such as Push-Pull technology (PPT) as a way of addressing these constraints. Results revealed that continual uptake of PPT both in Kenya and Rwanda had a positive and significant effect on household consumption expenditure and household dietary diversity, with a negative impact on poverty [62,65,67]. The International Centre of Insect Physiology and

Ecology in Kenya has largely promoted PPT as an integrated pest and weed management technology with the aim of reducing maize and sorghum yield losses due to stem borers, fall armyworm, and parasitic Striga weed infestations [7,24,68]. Additionally, the technique minimizes the use of agrochemicals, boosts soil fertility and moisture, enhances livestock feed, and lowers production costs, all of which enhance the livelihoods of small-scale farmers both locally and nationally. The push that desmodium uses to ward off stem borers, fall armyworms, and stop Striga attacks is the mechanism at work [22]. The pull is where autumn armyworms and stem borers are drawn to and killed by napier grass. Hence, Desmodium and napier grass became additional sources of income and feed [46,53].

4.3. CS-IPM Put in Place Developing Climate Responsive National Extensive System, No Chemical Technic and Resistant Plant Varieties Impact on Key Small Holder Households' Social Welfare Aspects

Agriculture and investment policies have ensured the adoption of appropriate CS-IPM practices in some African societies, such as the Yatenga of Burkina Faso, Northern Cameroon, and the Nile Delta of Egypt. In the short term, this has reduced food insecurity and poverty for smallholder households, and over the long term, it has considerably lessened the impact of climate change on food security [45,69–71]. Amongst the Coastal rice farmers in Southern Bangladesh, the adoption of CS-IPM practices such as saline-tolerant and flood-tolerant crop varieties, pond-side vegetable cultivation, and rainwater harvesting for irrigation were found to improve household food security significantly [1,14,56]. By raising farm productivity, lowering the danger of pests and diseases, and employing stress-tolerant varieties in particular, CS-IPM methods are leading the charge in Uganda to combat poverty, which is being hastened by climate change [46,69]. More specifically, in Northern Uganda, stress-tolerant varieties of cereals have been observed to reduce the cost of production and lower the economic risk of investing in agriculture [32,71]. The adoption of stress-tolerant varieties and crops as CS-IPM technologies in SSA nations is thus seen as a means of enhancing farm households' welfare, with a focus on raising farm output at the household level [4,23,72]. From such increased farm yield and productivity, CS-IPM practices adopting households gain sustainable improvements in nutrition [73,74]. Indeed, increased productivity boosts household food supply for both domestic consumption and commercial purposes, thus ensuring sustainable increases in food production, which consequently increases stability in food supplies and family incomes, hence reducing food and financial poverty among farming communities [30].

In Zimbabwe, evidence from Mujeyi et al. [30] and Radeny et al. [75] show that cooperation between ministries and extension organizations has led to intensified use of CS-IPM practices, including the use of drought-tolerant (stress) maize varieties. These varieties contributed to increased maize harvests among adopters and reduced exposure to negative risks [76]. Moreover, the results from [54] study indicate that the perceived benefits of PPT adoption and its effectiveness in pest management, were strong in Rwanda farmers according to their farmer's association group participation and their gender. These findings provide a strong rationale for advising that development initiatives should prioritize improving knowledge about the presumed benefits of TPP adoption through gender-disaggregated group processes [8]. The adoption of IPM is severely hampered by farmers' views against pesticides, according to a study [20] on gender and pest management uptake among smallholder coffee farmers in Uganda. The study looked at the relationship between gender and pest management uptake. Farmers believed that using pesticides made pest management easier, increased yields among farmers according to their gender were produced and made high-quality coffee more enticing to consumers.

5. Discussion

According to [68], while the adoption of drought-tolerant crops, for instance, was found to have a positive and significant impact on household income in the Nyando basin of western Kenya, Ogada et al. [68] claim that a change in household income led to an increase in asset units, so adoption of drought-tolerant crops was seen to increase household income by 83%. In fact, it has been shown that CS-IPM technologies and practices, particularly the use of organic manure, mulching, and crop rotation, which are comparatively inexpensive to adopt, are widely accepted and effective strategies to escape poverty, especially when correctly targeted [9,52,65,71]. Some cases rely heavily on crop production as a source of income, necessitating the use of crops that are resilient to climatic hazards. This illustrates that there are some situations where households are more likely to be food secure and be able to supplement their dietary needs if there are such things as a better educational level, farming as a major occupation, a larger pond size, more cattle, higher household income, smaller family size, and less difficulty with access to markets, among others [77].

It was found that improved food security for households, decreased GHG emissions, wealth accumulation, and income sources [78,79] play a significant role in smallholder livelihoods. In the same way, the data from the Nyando basin of Western Kenya showed that using resilient livestock breeds proved effective in reducing food insufficiency among households [68]. The fact that while implementing CS-IPM practices, farmers do diversify crop production, such improves and increases the number of food varieties available to households, thereby enhancing household dietary diversity [77]. Similar to this, tolerant cattle breeds increase animal production and produce food such as milk, eggs, and meat that directly affects human nutrition [53,72,80]. It is also crucial to remember that households may sell extra farm products from these tolerant crop types and livestock breeds in order to pay for food that is not grown on-site. Haq [54] asserted that CS-IPM practices' adoption also helped not only to reduce poverty among smallholder households in countries such as Pakistan but also aided in checking on poverty severity and improving household food and nutrition security sustainably. Therefore, CS-IPM practices helped to boost farm productivity and household incomes [4,81]. Additionally, CS-IPM practices, through improved food and nutrition security, do reduce malnutrition and associated diseases, thus promoting human health, especially among the vulnerable groups of the population, for instance, children, youth, and women [16,30]. Moreover, while women produce more than half of the food grown worldwide, they produce 20–30% less yield than males due to, among other factors, reduced access to agricultural information and inputs. Therefore, gender-responsive planning is a critical pillar for the success of CSPM [1]. Hence, IPM practices can be a source of income in food production for smallholder farmers, enabling them to support themselves and their families [25]. These practices can enhance smallholder's production capacity, which may allow them to consume and sell at the local market [82]. This can improve food security, enhance social welfare by reducing poverty by improving the standard of living, creating jobs, and contributing to a range of positive environmental outcomes [12,26] and lead to enhanced social welfare by promoting a healthier and more sustainable food system. The results also revealed that CS-IPM procedures also have the potential to improve resilience and coping mechanisms of food production through monitoring and effective management of greenhouse gas emissions, which can help to address the impact of Climate Change on agriculture and the environment [10,18].

Table 1 below presents some key reviews of the impact of CS-IPM practices. The 61 articles were taken into consideration, as stated in the methods section, for the extraction of the data shown in Section 3 of the results and discussions. Under this latter section, we single out key articles for the readers that outstandingly documented the impact of CS-IPM practices on strategic welfare aspects of households, for instance, food security, nutrition, household incomes, and poverty reduction, among others. We present these key reviews in Table 1.

Table 1. Some key studies on the impact of CS-IPM practices on household welfare.

References	CS-IPM Practice Studied	Key Result on Area of Impact
Teklewold et al., 2019 [83]	Diversification of the cropping system.Soil and water conservation. Conservation of water and soil.	Increase in dietary diversity. Improvement in calorie and protein availability.
Manda et al., 2019 [64]	Adoption of improved cowpea varieties.	Increased per capita household income. Increased asset ownership by 17 and 24 percentage points.
Lipper et al., 2014 [71]	Crop, livestock, and aquaculture integration Agroforestry techniques. enhanced control of pests, water, and nutrients. improved forestry and grassland management.	A short-term reduction in poverty and food insecurity. helping to lessen the long-term threat that climate change poses to food security
Nyasimi et al., 2017 [14]	Improved crop varieties, agroforestry, and scientific weather forecast information.	Increasing agricultural productivity and incomes. Minimizing agriculture's contribution to greenhouse gas emissions.
Hasan et al., 2018 [63]	Tolerant of salinity crop cultivars. crops tolerant of flooding. Rice that matures quickly, vegetables grown in a floating bed, and the "sorjan" farming method. vegetable farming around a pond. Relay trimming and deep urea placement. Mulching and organic fertilization. pheromone trap usage. collecting rainwater. Glass bottles or plastic bags are used for seed storage.	Enhancement of food security.
Steenwerth et al., 2014 [84]	Water management for fisheries and food production. Managing forest biodiversity.	Economic expansion food security and the reduction in poverty. preserving and increasing farm production.
Scherr et al., 2012 [59]	Management of nutrients, water, and soil. management of livestock, husbandry, and agroforestry. strategies for managing grasslands and forests.	Improved rural lives and food security. facilitating adaptation to climate change.
Arslan et al., 2015 [85]	less tillage. Intercropping of legumes with crop rotation. use of inorganic fertilizer and better seeds.	Increased productivity and the resilience of smallholder farmers in Zambia.
Rosenstock et al., 2019 [46]	Reduced tillage. Water harvest/storage. Increased diversity of crops. Intercropping with Legumes.	Improve the livelihoods and food security. resilience in the face of climate change realities.
McCarthy et al., 2011 [62]	Agro-forestry. Conservation agriculture. Cropping patterns. Grazing land management.	Food security. Soil conservation for prolonged productivity.
Taylor and Martin, 2018 [56]	Rainwater harvesting for peasant agriculture. no-till mono cropping.	Increased food production, distribution, and consumption.
Imran et al., 2018 [73]	Conjunctive use of water. Drainage management. Minimum tillage. Crop rotation and improved varieties.	Higher yield and financial returns. Improved gross value of cotton product.
Abegunde et al., 2019 [86]	organic manure, crop rotation and crop diversification	Improved household incomes.

Table 1. *Cont.*

References	CS-IPM Practice Studied	Key Result on Area of Impact
Khatri-Chhetri et al., 2016 [87]	crop varieties that are better. land leveling with lasers. tilling. Residue control. Site-specific control of nutrients	Improved crop yields in rice and wheat. Improved net return (income for farmers).
Onyeneke et al., 2018 [88]	Adjusting agricultural production systems. Diversification on and beyond the farm.	Improvement of ecological resilience. Increase in agricultural productivity.
Bai et al., 2019 [47]	Conservation tillage. Cover crop. Bio char application.	Reduce greenhouse gas emissions. Increased crop productivity.
E. Bagley et al., 2015 [89]	No-till agriculture. Retaining crop debris.	Retain or improve crop yields. Retain soil quality. Increase climate resilience.
Imran et al., 2019 [90]	Water-smart practices. Energy-smart. Carbon-smart. Knowledge-smart.	Improved agricultural productivity. Enhanced farm income on a sustainable basis. Enhanced water and nutrients use efficiency. Resilient to climatic stresses.
Makate et al., 2018 [76]	Conservation agriculture, drought tolerant maize, and improved legume varieties.	Farm productivity and income.
Shahzad et al., 2021 [32]	Changing input mix. Changing cropping calendar. Diversifying seed variety. Soil and water conservation measures.	Improved farm net returns. Reduced farmers' exposure to downside risks and crop failure.
Zougmore et al., 2018 [91]	High yielding drought tolerant crop varieties. Climate information services. Agroforestry. Water harvesting techniques. Integrated soil fertility management practices.	Sustainable improvement of farm productivity. Rural livelihoods and adaptive capacity of farmers.
Khatri-Chhetri et al., 2020 [81]	Direct seeded rice. Green manuring. Laser land leveling.	Reduce women's drudgery in agriculture. Improvement in productivity and farm income.
Kakzan et al., 2013 [15]	Use of agroforestry. Conservation agriculture.	Increased yields. Reduced vulnerability to climate change. Reduced greenhouse gas emissions.
Ayoub et al., 2022 [39]	Insect pests under changing climate and climate-smart pest management	CSPM also contributes to climate change mitigation; reducing pest-related yield losses.
Fentie & Beyene, 2019 [8]	Row planting technology.	Improved per capita consumption. Increased crop income per hectare.
Hanley et al., 2021 [77]	Diversification and intensification of key CS-IPM strategies such as Integration of fruit trees in farms.	Diversifying and improving the quality of food consumed by households.
Sarker et al., 2020 [69]	Zero tillage systems. Altering the period of irrigation. Pest resistant varieties.	Increased agricultural production and income of poor households.
Robert Ochago, 2018 [25]	The effect of CS-IPM practices on gender roles among smallholders cofee in Uganda	Using pesticides makes managing pests easier, results in increased yields, and creates high-quality coffee that appeals to consumers. Because of their high labor needs and expense, CSB IPM procedures are less desirable and hence a restraint, especially for women and the elderly.

Table 1. *Cont.*

References	CS-IPM Practice Studied	Key Result on Area of Impact
Mwadzingeni et al., 2022 [61]	Pest management in irrigated agriculture and the prevalence of gender in the context of climate change irrigating techniques	Pest prevalence and pest management strategies differ by gender. Development of smallholder irrigation farming system and scientific research.
Murage et al., 2021 [92]	Push-Pull Technology as a Climate-Smart Integrated Pest Management Strategy	Push-pull technology (PPT) reduces yield losses due to fall armyworm (FAW). PPT increased maize yield by for the adopted farmers.
Gwada et al., 2021 [93]	Effect of integrated pest management technology on the livelihoods of small-scale maize producers	Uptake of PPT had a positive and significant effect on household consumption expenditure and household dietary diversity
Henk van denberg and Jiggins, 2007 [5]	Investing in Farmers—The Impacts of Farmer Field Schools in Relation to Integrated Pest Management	Participatory training approach in changing crop protection by farmers from chemically dependent, to more sustainable practices in line with the tenets IPM.
Mazid et al., 2013 [94]	Improved livelihoods of smallholder farmers in Iraq through integrated pest management and use of organic fertilizer	Increases in the productivity of date palm and cereal/food/legume-based production systems can be achieved

6. Theoretical and Methodological Implication

Much of the work on CS-IPM has listed and described tactical solutions separately, in specific contexts, rather than scientifically understanding the benefit of using them synergistically for small households' welfare [50,95,96]. Moreover, in most situations, the studies are based on a single pest, a single crop, or a specific context, without a broader approach that takes into account all pests or even all management constraints faced by farmers in a non-generic socio-technical package that does not provide adjacent solutions. Unlike other studies [34,35,55,66,93,97,98] and based on a synergetic manner, this paper relied on electronic databases to gather and identify the published literature related to CS-IPM on welfare, in particular using Web of Science (WoS), Google Scholar (GS) and Scopus accountant as they are contains a large number of up-to-date studies [99]. In addition, have the highest percentage of citations in all fields [50,62,99,100]. They allowed the research team to access and review several studies on the impact of IPM on key aspects of social welfare [5]. Furthermore, the study is congruent with the Theory of Reasoned Pursuit of Goals (TRGP) [40], in the sense that the desire to engage in agricultural activity depends primarily on the perceived probability that the application of agricultural skills will lead to the achievement and success of agro-food and improving welfare development goals [41]. Thus, the study came to demonstrate that farmers might be motivated when the choice can have positive effects on society, environment and welfare. By proceeding in the following way, the paper elucidates many evidence and benefit of applying CS-IPM practices on household's welfare around the world in general and in Sub Africa particularly. Hence, these contribution approaches appear to be relevant in CS-IPM studies.

7. Limitation

This paper aims to examine the impact of CS-IPM practices on key aspects of the social welfare of smallholder farm households. It used a rigorous meta-analysis methodology in order to identify relevant articles. Nevertheless, the study suffered from a lack of direct farmer involvement in the research. Future work could examine the role of other means that promote CS-IPM practices on household welfare beyond the theoretical review approach used in this study by combining multiple sources and empirical methodologies, not just Google Scholars, Scopus, and Word of Sciences as the main reference source used in this study to explore CS-IPM and smallholder's issues. Finally, as CS-IPM is a dynamic and evolving strategy, continuous monitoring and evaluation are needed to assess the implementation, immediate outcomes, and implications of CS-IPM interventions, as well as to allow for ongoing re-evaluation of tools and methodologies. Farmers' participation in the study and investigation could influence the findings because of their in-depth understanding of traditional pest control techniques as well as beneficial insects, pests, and other living facilities.

8. Conclusions

In this review, we examine and make an effort to comprehend how CS-IPM techniques affect important facets of smallholder farmer households' social well-being. We select from the other articles that are more succinct and focused on the target welfare aspects such as farm productivity, food security, nutrition, and household income, among others, after using a rigorous meta-analysis review methodology to identify relevant articles using their titles and abstracts for keywords of interest. In a nutshell, the review found that, in general, CS-IPM practices improved conservation and farm productivity of both crops and livestock, thus consequently increasing farm yields that led to better household food and nutrition security, as well as stable farm household incomes and welfare. Adoption of drought-tolerant seeds, for example, increased crop yields, raised farm output volumes for both home consumption and marketing, smoothing out family food and nutrition security. Improved incomes can then be used to achieve secondary welfare gains to households, for instance, diversified diets, education, and healthcare services, thus sustainably boosting the livelihoods of farming households. Although science has directly addressed the problem of pest management in smart farming for smallholder livelihoods and the need to take into account and revisit current preventive agricultural practices and integrated pest management (IPM) strategies, the knowledge is frequently specialized to a particular pest or geographical area. In order to enhance the application of CS-IPM worldwide and in Africa in especial, the support of research institutions, NGOs, and state institutions is needed to share knowledge, information, and innovative solutions and to jointly address the challenges caused by transboundary pests. Furthermore, by bringing together the problems faced by researchers and farmers, the latter could be trained on the different practices available to them and, more importantly, the importance of making them reliable and scaling up CS-IPM practices.

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