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A Farming System Approach to Exploring Drivers of Food Insecurity Among Farm Households in Developing Countries: The Case Study of Mozambique

Máriam Abbas [1,2,*], Paulo Flores Ribeiro [3] and José Lima Santos [3]

1 Observatório do Meio Rural, Faustino Vanombe 81, Sommerchield, Maputo 0101-11, Mozambique
2 Centre for African and Development Studies/Research in Social Sciences and Management, Institute of Economics and Management, University of Lisbon, Rua Miguel Lupi, nº20, 1249-078 Lisbon, Portugal
3 Forest Research Centre, Associate Laboratory TERRA, School of Agriculture, University of Lisbon, Tapada da Ajuda, 1349-017 Lisbon, Portugal
* Correspondence: mariamabbas1502@gmail.com

Abstract: Farm households, especially in developing countries, are among the most vulnerable to food insecurity and poverty. A farming system approach is largely recognized to play an important role in supporting strategies to improve food security and alleviate poverty among farm households. This paper aims at exploring the drivers of food insecurity among farm households in developing countries, using a farming system approach. It also aims to explore farm households' perceptions regarding the causes of food shortages and the adopted coping strategies, and how these vary across farming systems. This analysis was based on data extracted from an agricultural census, which were analyzed through scatter plots and plot means with 95% confidence intervals. The results indicate that the factors analyzed (level of specialization, market integration, use of yield-raising and labor-saving inputs, farm size, population density, and rainfall) are important drivers explaining food insecurity among farm households, highlighting important differences across farming systems. The analysis also showed that farm households' perceptions regarding the causes of food shortages are related with the abovementioned drivers of food insecurity. Our findings suggest that less specialized farming systems with better access to markets, using yield-raising and/or labor-saving inputs, are more likely to be food secure. The farming system approach proved to be a useful approach to explore food insecurity drivers and coping strategies as well as to support policymaking. Moreover, the use of an agricultural census data provides an easily attainable tool to access and analyze farm-level data for policy analysis and to explore and understand a range of issues affecting farm households in developing countries.

Keywords: farming systems; food security; coping strategies; policy design; Mozambique

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1. Introduction

1.1. Background

Global hunger has remained high in the last decade, with higher levels being observed in developing regions [1]. Poverty alleviation and food security have been at the top of the policy agenda in many developing countries, with the implementation of several development programs and strategies over the years. Despite this, Africa continues to be the region with rising and highest prevalence of undernourishment (20.4% of the population) and moderate or severe food insecurity (58% of the population), being far from meeting the food security and nutrition targets of Sustainable Development Goal 2 (SDG 2) and the Malabo Declaration [2].

Most food insecure people in developing countries live in rural areas, where poverty is predominant, depending on agriculture and natural resources for their livelihoods, thus being among the most vulnerable to shocks, such as those associated with climate change [3,4]. Africa is considered to be the most vulnerable and least prepared developing region in the World, to have to deal with the impacts of climate change [5], which will translate into significant increases in hunger and food insecurity if no action is taken.

In many developing countries, food insecurity is seen as a consequence of inadequate policies, not only related to the agricultural sector, but also with development policies [6,7]. Poverty has been considered one of the biggest drivers of food insecurity (i.e., low socioeconomic development) which, if associated with climate-related disasters, exacerbates food insecurity [3,8–10]. Therefore, poverty plays an important role in contributing to both climate and food insecurity vulnerability.

Considering the close relationship between food insecurity and poverty, one can also argue that to address food insecurity, one must address poverty. Persisting poverty contributes to entitlement failure, and the collapse of entitlements undermines the capacity of families to achieve household food self-sufficiency and security [11]. Achieving food security, especially in Sub-Saharan Africa, therefore requires policies and actions that are integrated with efforts to reduce poverty, enhance livelihoods and incomes, and increase agricultural output, while also considering the underlying structural factors (historical and contemporary processes) affecting agriculture [11]. Then, food insecurity can be seen as a structural problem, requiring long-term and integrated policies. Nevertheless, it is also true that many African countries have failed to adequately address food insecurity, both in the short- and medium- or long-term. While recognizing that long-term, integrated policies are of utmost importance to address food insecurity in developing countries, this paper considers that it is also important to address food insecurity in the short-term to avoid deepening food insecurity. That is, although poverty alleviation and socioeconomic development are important factors contributing to improve food security [11], it is also important to acknowledge that people are not passive victims of food insecurity and hunger, but active actors in responding to the risks and situations they face in their daily lives, including food shortages [12]. Therefore, it is important to understand how, even in the context of extremely low socioeconomic development, farm households respond and cope with food insecurity.

1.2. A Farming System Approach to Food Insecurity

Governments in developing countries have been criticized for their failure in achieving these relevant societal goals (i.e., reducing poverty and improving food security), as most of them usually adopt one-size-fits-all policies [13,14]. To maximize rural and agricultural development and contribute to improve food security among rural farmers in developing countries, the heterogeneity of farm households should be considered in policy design and implementation [13,15–17]. Households' experiences and responses to food insecurity may differ based on the context and circumstances they live on [12,18,19]. One way of dealing with this heterogeneity is through a farming system approach (FSA), aggregating farms into groups with similar production patterns, i.e., similar farm-level decisions regarding what and how to produce [3,8,17]. The conceptualization and evolution of the FSA have been significant, evolving from a focus on the farmer, which had the central role in farming systems development [3,20], to a broader approach focusing on the household and their livelihoods, aimed at agricultural development, natural resource management, market access policies, societal goals, and others [3]. Since then, the FSA has been widely used, e.g., for policy analysis [21], and to explore issues such as food security [22,23], poverty [3,22,24], climate change [8,25–27], agricultural innovation [15], household livelihoods' strategies and behaviors [13,28], biodiversity and ecosystem services [29], among others.

Food security and poverty levels differ considerably across farming systems, and the strategies used by families to cope with food shortages also vary according to the resources available to them (i.e., the farming system) [17]. Therefore, understanding the characteristics of the main farming systems in a region provides a consistent framework to address food security problems while integrating agricultural diversity and exploring fitted solutions for each case [3,17,23,24,26]. Moreover, the FSA allows the rationality behind farmers' decisions to be understood, which provides the basis for understanding how government policies may affect farmers' management and decision making, and therefore food security levels [8,14,17,29]. An understanding of how food-insecure farm households behave (i.e., coping strategies adopted) also gives useful insights for policymakers.

Some studies explored food insecurity coping strategies adopted by different socioeconomic groups [18], or between rural and urban settings [12]. However, there are little or no studies exploring coping strategies adopted by farm households in different farming systems. Considering that the rural population, in particular farm households, is considered the most vulnerable to food insecurity, it is important to understand how coping strategies vary across farming systems.

In this context, this study aims at exploring the following: (i) the drivers of food insecurity affecting farm households across farming systems; (ii) the association between farm households' perceptions regarding the causes of food shortages and the drivers of food insecurity; and (iii) the coping strategies adopted across farming systems. This paper does not assume that the strategies presented and discussed in objective (iii) are the solutions to improving food security among farm households in developing countries. Instead, we argue that an understanding of the drivers and adaptation strategies adopted by food insecure farm households, based on an FSA, offers relevant insights for policy design and evaluation in a way that it can contribute to meeting food security objectives for farm households in developing countries in the short-term. This knowledge will provide a basis for policymakers to make short- and medium-term decisions that will allow farm households to reduce their vulnerability considering the resources currently available to them (in their farming system). This analysis aims to contribute to better policy design focused on improving food security in developing countries, where poverty is a reality and agriculture plays an important role in farm households' livelihoods.

Mozambique was chosen as a case study, as it is considered one of the poorest countries in the world, with high levels of food insecurity and where agriculture is the main source of income, subsistence, and employment for the majority of the population, with farm households being the most vulnerable to food insecurity—as it is the case of many other developing countries where the farming system approach has just begun to be explored (e.g., [8,30]).

This paper has five sections: Section 1 is the introduction where we describe the scope and objectives of the paper, review the literature, and present the state of the art, focusing on the farming system approach and its usefulness to explore food insecurity in developing countries. Section 2 refers to materials and methods, where we describe the study area, the baseline data, and the statistical analyses performed. Section 3 presents the main results, focusing on the drivers of food insecurity across the farming system, as well its association with farm households' perceptions of the causes of food shortages, and the corresponding strategies adopted to alleviate food shortages, across farming systems. This is followed by a discussion in Section 4, and conclusions in Section 5.

2. Materials and Methods

2.1. Study Area

Mozambique is located on the southeastern coast of Africa (Figure 1), being characterized by a humid climate in most central and northern regions and a semi-arid climate occurring in the south-west and upper Zambezi Valley, in the central region [8,17].

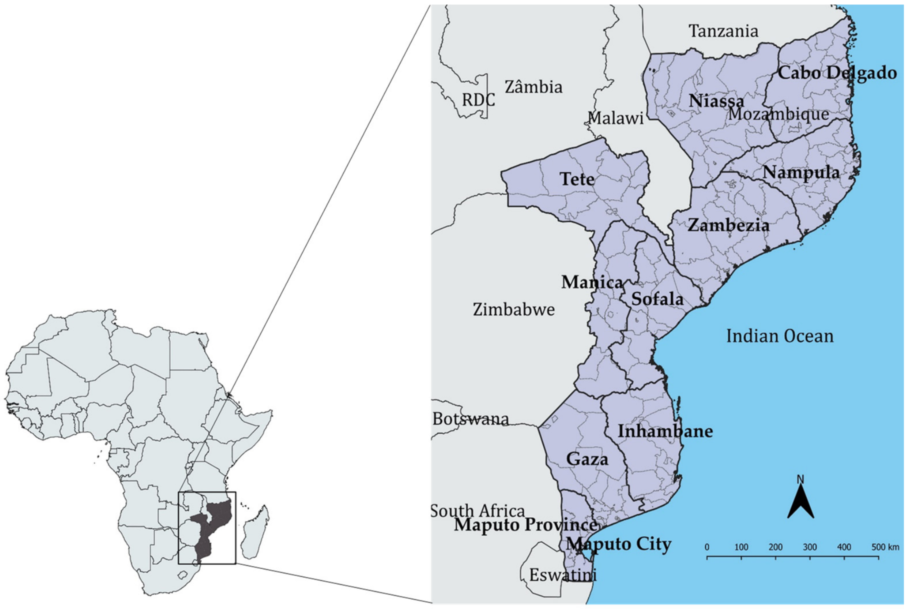


Figure 1. Administrative division of Mozambique (provinces are named; district boundaries in grey).

In terms of poverty, estimates indicate an increase in consumption poverty, from 46.1% in 2014/15 to 65% in 2022 [31], being higher in rural areas where two thirds of the population is concentrated. The agricultural sector is considered by the Constitution of Mozambique as the basis for development and a priority sector of the economy [17]. Its potential role in decreasing poverty and improving food security in the country is highly recognized [32], as it is a major source of employment, subsistence, and income for most of the population (ca. 70%).

The agricultural sector is dominated by smallholders—family farms—which account for 99% of all farms [33]. Agriculture is mostly rainfed (98% of the farms), thereby being extremely dependent on rainfall [17]. The country's agroecological potential for agriculture is heterogeneous, encompassing ten agroecological zones [34], with variable agricultural suitability, which are defined mainly by rainfall and soil type [17].

Most of the domestic food (ca. 95%) is provided by small farmers. The production is dominated by roots and tubers (especially cassava), cereals (maize, millet, sorghum, and rice to a certain extent), groundnuts, and legumes (horticultural crops) [17]. Basic food crops are mostly for households' own consumption, and only marginal surpluses are sold in local markets [17,35]. Important cash crops are tobacco, cotton, sugar cane, sesame, and soybean in recent years [36].

The latest reports on food and nutrition security for Mozambique indicate that 24% of households are considered chronically food insecure [37], 50% are acutely food insecure [38,39], and 56.5% of the population had food shortages in 2022 [40]. Food insecurity is higher in rural areas, being predominant in areas where most of the food is produced (central and northern regions). Households depending on agriculture are the most vulnerable to food insecurity in Mozambique [37]. Total food production in Mozambique varies significantly both inter-annually and seasonally. Low levels of market integration and poor availability of foreign exchange to meet food needs through imports also pose additional challenges to food security in the country [17,32].

2.2. Data

2.2.1. Farming System Typology

This paper uses a farming system (FS) typology developed for Mozambique by Abbas et al. (2023) [8]. Farming systems are defined as a population of individual farm systems that have broadly similar resource bases, enterprise or productive patterns, household livelihoods, and constraints, and for which similar development strategies and interventions would be appropriate [3]. The farming system, as defined by Abbas et al. (2023) [8], represents a set of individual farm households with similar productive decisions regarding land use and cover, livestock composition, and yield-raising and labor-saving input use. Under this concept, farms operating the same farming system are thereby expected to react similarly to external stimuli, such as climate, market prices, or policy changes.

Abbas et al. (2023) [8] developed a new approach for the classification of farms by farming system in developing countries, based exclusively on agricultural census data that directly reveal farmers' productive decisions, which distinguishes it from approaches adopted by previous studies [3,41]. Thus, the FS typology presented describes the choices made by farmers, which are taken as the broader set of possible options available for farm households in the study area [8].

Abbas et al. (2023) [8] used data from the 2009–2010 Mozambique agricultural census to derive the FS typology. The 2009–2010 agricultural census, although not recent, is the latest agricultural census to date, providing detailed and comprehensive data collected at the farm-level (including data on land use and cover, livestock, agricultural practices, input use, value of production, production resources, food security, etc.), from a representative sample of farm households in the whole country. More recent databases (such as the agricultural integrated surveys) are less comprehensive and do not include food security data. Abbas et al. (2023) [8] analyzed the data at the farm household level—a farm referring to all parcels of land managed by the same household [17]—from a sample of 27,805 farm households [8]. Only small and medium farms—as defined in the agricultural census [33]—were included in the analysis, accounting for 99% of the total farms in Mozambique and which concentrate most of the food insecure population [33]. A set of variables (Table A1 in Appendix A) representing farm households' productive decisions regarding agricultural land use and cover, livestock composition and density, yield-raising (i.e., fertilizer, pesticides, and manure), and labor-saving (mechanical or animal traction) input use was then used to derive the FS typology, through principal component and hierarchical cluster analysis [8]. Sixteen farming systems were derived by Abbas et al. (2023) [8], representative of the main FS in Mozambique, whose spatial distribution was mapped at the district level (second administrative division of Mozambique) (Figure A1) [8]. Figure 2 presents the spatial distribution of these farming systems by zones, representing districts (second administrative division) with similar farming systems composition (pie charts in Figure 2) [8].

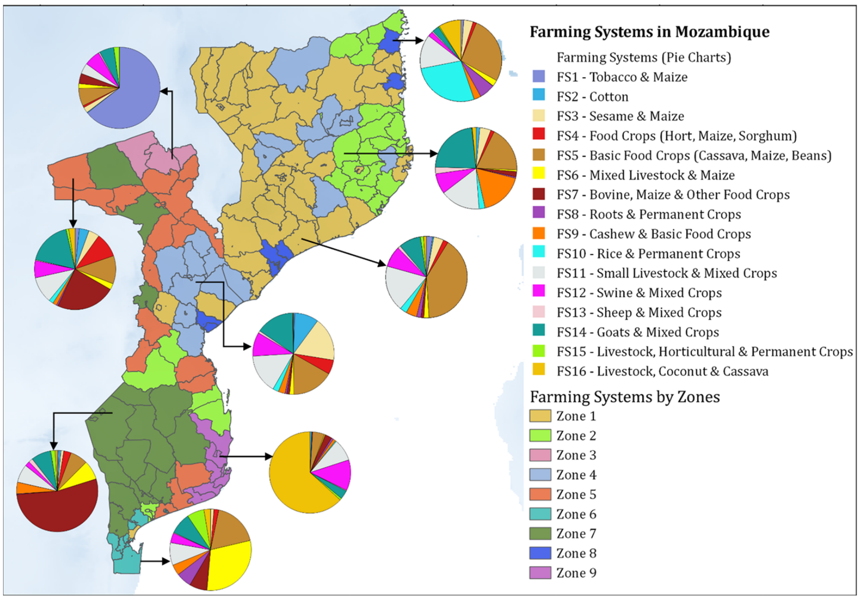


Figure 2. Farming systems' spatial distribution in Mozambique. Source: Abbas et al. (2023) [8].

The main characteristics of each of the 16 farming systems are presented in Table 1.

Table 1. The farming systems of Mozambique and characterization of the representative farm household.

Farming System	Description
FS1. Tobacco and Maize	A market-oriented FS (on avg. 35% of the output is sold), where farmland is mostly composed by tobacco (40%), maize, and beans (36% collectively), using yield-raising inputs such as fertilizers and pesticides (on avg. applied on 55% and 14% of farmland, respectively). Low livestock density (0.60) including chickens and goats. Farms are mostly managed by men (85%), with a farm size of 2.3 hectares (ha), and the household usually has 5 members.
FS2. Cotton	Farmland is mostly dedicated to cotton (57%), other crops include maize, sorghum, and beans (covering together 26% of the farmland). On avg. about 1/4 of the area uses pesticides. Low livestock intensity (0.88), including small and large livestock (e.g., chickens and cattle). Integrated in the market. The farm size is 1.8 ha and the household has usually 5 members. Farms are mostly managed by men (87%).
FS3. Sesame and Maize	Maize and sesame occupy, on avg., 31% and 27% of the farmland, respectively. Other crops include beans, cassava, sorghum, and others. Low livestock-density (0.55), with chickens and goats. Farm households do not use yield-raising inputs. Integrated in the market. On average, farm size is 1.4 ha and the household has usually 5 members. Farms are mostly managed by men (77%).
FS4. Food Crops	Farmland is mostly dedicated to horticultural crops (32%), maize (26%), sorghum (18%), and beans (9%). Very low livestock density (0.20), with only a few chickens. Does not use yield-raising inputs. On average, the farm size is 1.1 ha, with 5 household members and 41% of farms are managed by women.
FS5. Basic Food Crops	Most of the farmland is used to produce cassava, Leguminosae (beans and groundnuts), and maize; with the lowest livestock density (0.14). Farm households do not use yield-raising and labor-saving inputs while 40% of farms are managed by women and have, on average, 1 ha and a household size of 5 members.
FS6. Mixed Livestock and Maize	On avg. 3/4 of the area is dedicated to food crops such as maize, Leguminosae, and cassava. Nevertheless, this is one of the few FS that also produces horticultural crops and rice (occupying on avg. 10% and 6% of the farmland). Livestock density is higher (2.40), with a variety of animals, including chickens (14 on avg.), bovine (6), goats (4), pigs and sheep (1 of each). Most farm households use tractors (96%) and some use bovine traction (43%). Farm size is about 2.3 ha, and the household has on avg. 7 members while 44% of farms are managed by women.
FS7. Bovine, Maize, and Other Food Crops	Farmland is dedicated mostly to food crops, including maize (46%), horticultural crops (15%), beans (13%), cassava (11%), groundnuts (8%), and rice (6%). The highest livestock density (6.12), with mostly cattle and 87% of farms use bovine traction. Mostly managed by men (70%), with farm size of 2 ha, and the largest household (on avg. 8 members).
FS8. Roots and Mixed Permanent Crops	Farmland is mostly dedicated to roots and tubers (e.g., sweet potato and cassava)—on avg. 3/4 of the farmland. Permanent crops occupy ca. 1/4 of equivalent farmland (e.g., mango trees). Low livestock density (0.78). Farm size is less than 1 ha and 46% of farms are managed by women. The household size is 5.
FS9. Cashew and Mixed Basic Food Crops	Most farmland is dedicated to cassava (40%), Leguminosae (beans and groundnuts, 30%), and cereals (maize and sorghum, 26%). On avg. 27% of equivalent farmland has permanent crops, with ca. 80% being cashew trees. Extremely low livestock density (0.18) and 38% of farms are managed by women, with a farm size of 1 ha, and the smallest household size (4 members).
FS10. Rice and Mixed (Permanent Crops and Livestock)	On average 93% of the farmland is dedicated to rice and 17% of equivalent farmland includes permanent crops, with half of it with coconut and mango trees. Low livestock density (0.76). Farm size is less than 1 ha and 45% of farms are managed by women, with households of 5 members.
FS11. Small Livestock and Mixed Crops	The farmland is dedicated mostly to food crops (maize, cassava, Leguminosae, and sorghum), with a few mango and cashew trees. Low livestock density (0.32) including only chickens. Farm size is 1.1 ha and 35% of farms are managed by women, with households of 5 members.

Table 1. *Cont.*

Farming System	Description
FS12. Swine and Mixed Crops	Like FS11, but with higher livestock density (0.87), including, in addition to chickens, also pigs.
FS13. Sheep and Mixed Crops	Like FS11 in terms of food and permanent crops produced. Medium livestock intensity (1.46), including sheep, chickens, and goats. Farm size is 1.3 ha and 77% of farms are managed by men, with households of 6 members.
FS14. Goats and Mixed Crops	Like FS13, but with slightly less livestock density (1.28) including only goats and chickens. Farms are managed mostly by men (69%).
FS15. Mixed Livestock, Horticultural, and Mixed Permanent Crops	The farmland is largely irrigated (86%), dedicated mostly to horticultural crops (on avg. 73%), with 27% of equivalent farmland with mango and other fruit trees. High livestock density (2.95) including a variety of animals, such as chickens, bovine, goats, and pigs. Integrated in the market, with intensive use of yield-raising inputs (37% of farmland uses pesticides, 43% fertilizers, and 54% manure). Farms are mostly managed by men (74%), with a farm size of 1 ha, and household size of 6 people.
FS16. Mixed Livestock, Coconut, and Cassava	The farmland is dedicated mostly to cassava (50%) and Leguminosae (30%). Permanent crops occupy almost 90% of equivalent farmland, with more than half of the area with coconut trees. High livestock density (2.54), including chickens, bovine, goats, and pigs with 60% of farms using bovine traction. Farms are managed mostly by women (51%), with farm size of 1 ha, and household size is 6 people.

Source: Abbas et al. (2023) [8].

2.2.2. Food Insecurity: Drivers, Perceived Causes, and Coping Strategies

The farming system typology developed by Abbas et al. (2023) [8] was used as a frame to explore the drivers of food insecurity, based on the reports of food shortages by farm households. It was also used to explore their perceptions on the causes of food shortages and the adopted coping strategies by farming systems. In the present study, food shortage was considered as an indicator of food insecurity, where a farm household was considered food insecure if it declared that it had experienced food scarcity in the last 12 months, meaning that farm household members were unable to consume the food that they would normally do. Food shortage data were extracted from the 2009–2010 agricultural census, being the most representative database including food security indicators at the farm household level available to date. Furthermore, the use of the same database for both the FS typology and food (in)security indicators allowed both the establishment of a direct relationship between food shortages (i.e., food insecurity) and farming systems and the exploration of its drivers and coping strategies across farming systems.

To explore the drivers of food insecurity, we considered, both descriptors (1–4) and drivers (5–7) of farming system choice: (1) level of specialization—which refers to the maximum contribution of a specific crop or livestock group for the total output (i.e., the proportion of a specific crop group or livestock type in total agricultural output); (2) market integration—which is given by the proportion of output sold; (3) yield-raising input intensity—the proportion of the farmland that uses yield-raising inputs (fertilizers, pesticides, manure, and/or irrigation); (4) labor-saving input intensity—proportion of labor-saving inputs used, considering the set of available labor-saving inputs (includes animal traction, tractors, etc.); (5) Rainfall—refers to the annual average rainfall (mm) computed based on average monthly rainfall for 1970–2000 collected from WorldClim 2.0, with a spatial resolution of 2.5 min [42]; (6) population density (inhabitants/km^2), based on data from the Mozambican Population and Housing Census 2007; and (7) farm size (in hectares)—extracted from the agricultural census (see Tables A3 and A4). The choice of these variables is explained by the fact that farm households' food security levels, especially in developing countries, are dependent on the farming system they adopt [8]. For instance, access to input and output markets is considered an important factor stimulating yields and contributing to increase farmers' income, which can then be used to purchase food in times of shortages [13,17,23,43]. Population density also plays an important role in explaining farming system choice, as population growth influences the availability of agricultural land per capita, therefore land use intensity and agricultural practices, which in turn impact food security [44–46].

Data extracted from the agricultural census were used to explore the perceived causes of food shortages (1) and the reported coping strategies adopted by farm households affected by food shortages (2) across farming systems. In this analysis, we considered perceived causes and strategies reported on average by at least 10% of farm households. In this sense, the perceived causes of food shortages by farm households include the following: (1) lack or irregularity of rain; (2) droughts; (3) pests; and (4) small farmland (Table A4). Adopted strategies to alleviate food shortages include the following: (1) reduce the time spent practicing agricultural activities to dedicate it to other activities; (2) use most of the household savings; (3) increase the practice of mutual aid with other families; (4) significantly reduce the quality of the diet (consume less meat, fish, and vegetables); (5) sale of large animals such as cattle, goats, and pigs; and (6) increase family labor in the farm (using other household members) (Table A4).

2.3. Statistical Analysis

To explore the drivers of food insecurity across farming systems, we analyzed the relationship between the occurrence of food shortages and the factors influencing farming system choice [8] through scatter plots with 95% confidence intervals, using the "ggplot2" package in R version 3.6.2.

To explore the relationship between farm households' perceptions regarding the causes of food shortages and the drivers of food insecurity, scatter plots with 95% confidence intervals were used. The variation of coping strategies adopted by farm households affected by food shortages across farming systems was analyzed through plot means. Both analyses were carried out using R 3.6.2.

3. Results

3.1. A Farming System Approach to Explore Food Insecurity

This section explores the drivers of food insecurity affecting farm households across farming systems in Mozambique; that is, it explores the associations between the likelihood of food shortages and possible factors (drivers) influencing food insecurity, across farming systems. It also explores farm households' perceptions regarding the causes of food shortages and how these relate with the drivers of food insecurity, as well as the corresponding strategies adopted by farm households to alleviate food shortages and how these vary across farming systems.

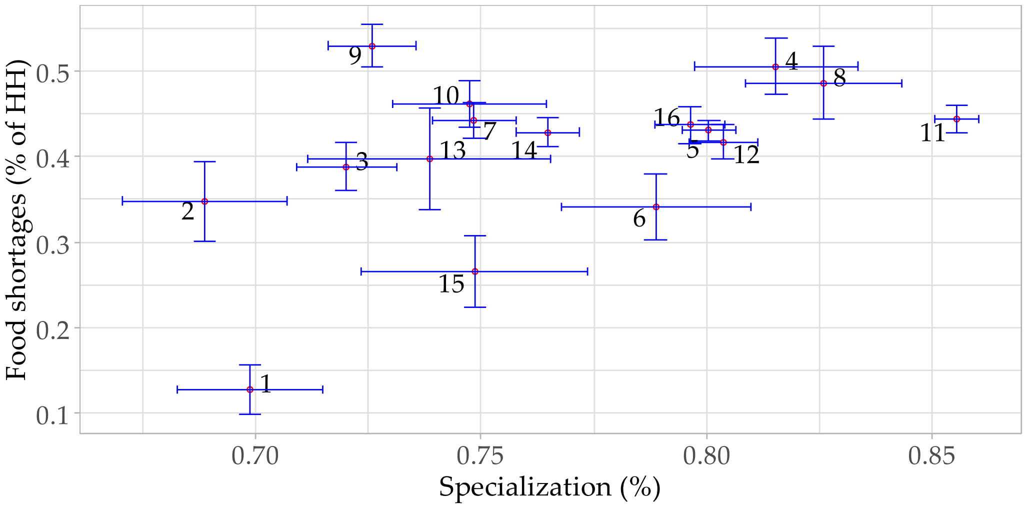
3.1.1. The Drivers of Food Insecurity

The results suggest that there is a slight positive relationship between the level of specialization and the likelihood of the farming system being food insecure (Figure 3a). For instance, highly specialized farming systems (e.g., FS4—food crops, FS5—basic food crops, FS8—roots and mixed permanent crops, FS11—small livestock and mixed crops, FS12—swine and mixed crops), deriving more than 80% of the output from a single crop group or livestock type, are considered either highly or moderately food insecure (Figure 3a). Mildly specialized farming systems (e.g., FS1—tobacco and maize and FS2—cotton) are among the most food secure farming systems. Nevertheless, FS15 (horticultural and mixed livestock and permanent crops) and FS6 (mixed livestock and maize) although moderately specialized are food secure, and FS9 (cashew and mixed basic food crops), although less specialized than FS15 and FS6, is the most food insecure.

On the other hand, the likelihood of farm households being food insecure decreases as market integration increases (Figure 3b). That is, FSs more integrated in the market are less likely to be food insecure. FS1 (tobacco) and FS15 (horticultural mixed), which are considered highly food secure, are also the ones with high use of yield-raising inputs (Figure 3c). FS6 (mixed livestock and maize) is the system with the highest use of labor-saving inputs, being also considered food secure; differing from FS7 (bovine, maize, and other food crops) which, although with some use of labor-saving inputs, is food insecure (44% of farm households reported food shortages).

Most food insecure farming systems, except for FS7 (bovine and maize), are predominant in areas with higher levels of rainfall (on average at least 950 mm) (Figure 4a). FS1 (tobacco), however, although predominant in humid areas, is the most food secure.

Except for FS15(horticultural mixed) and FS6 (mixed livestock), the most food secure farming systems (i.e., FS1—tobacco, FS2—cotton and FS3—sesame and maize) are in areas with low population density (less than 50 inhabitants per km^2). FS6, although relatively food secure, predominates in areas with the highest population density. Most food insecure farming systems are predominant in areas with 50–150 inhabitants/km^2. Regarding the likelihood of occurrence of food shortages in relation to farm size, the results indicate that the most food insecure farming systems (e.g., FS9—cashew, FS4—food crops, FS8—roots, FS10—rice and mixed permanent crops and livestock) have on average, smaller farms (less than 1.5 hectares). Food secure FSs, except for FS15 (horticultural mixed), have larger farms compared with other FSs.



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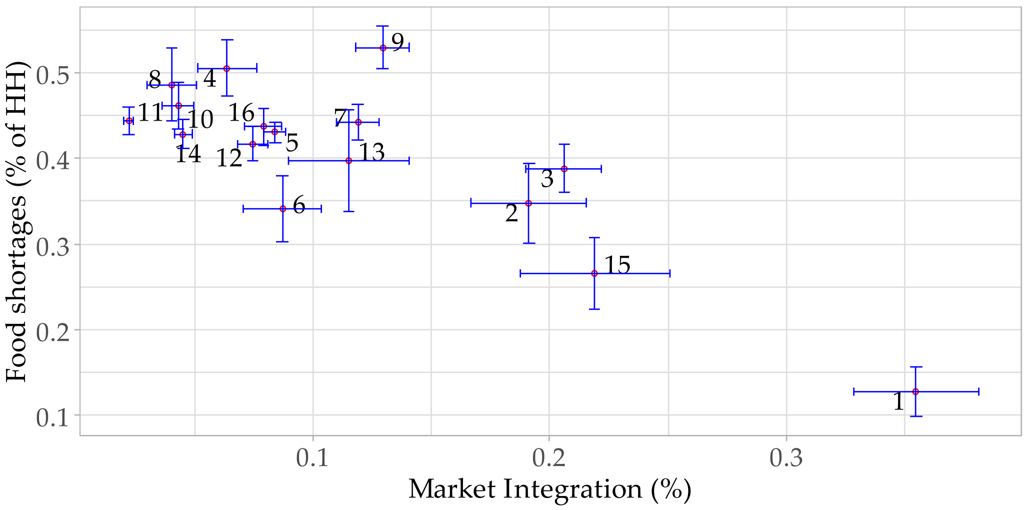

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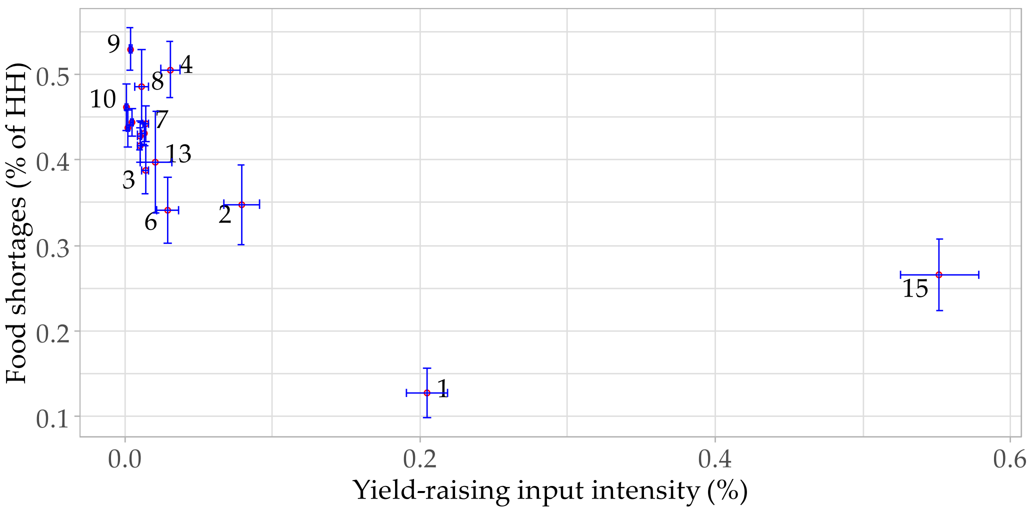

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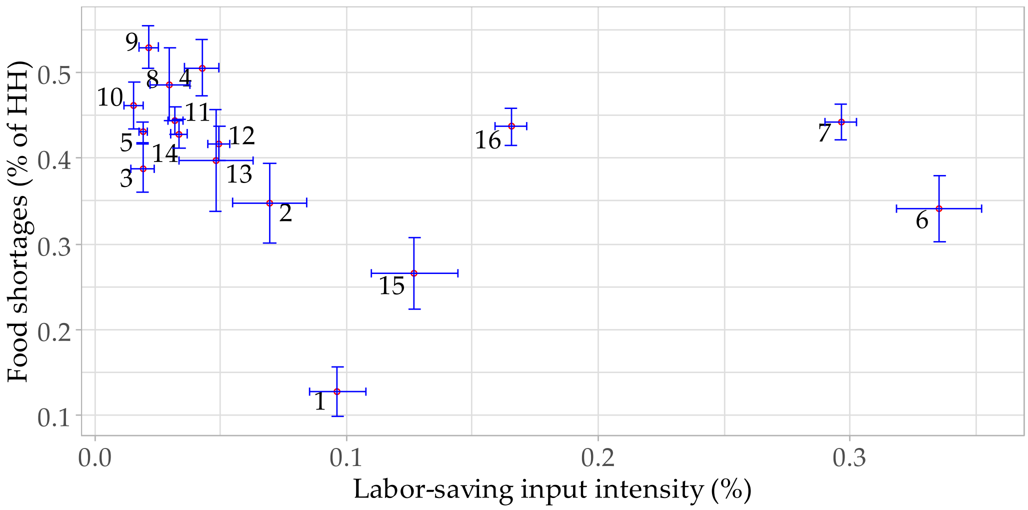
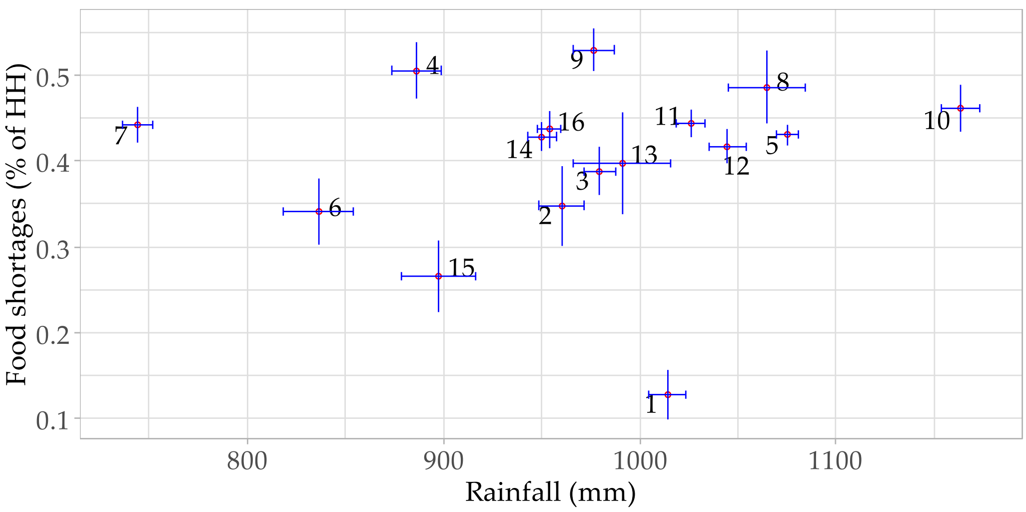


(**d**)

Figure 3. Associations between the likelihood of food shortages (% of farm households) and: (**a**) specialization (given by the proportion of a crop group or livestock type in the total output); (**b**) market integration (proportion of sales in total output); (**c**) yield-raising input use; and (**d**) labor-saving input intensity, across farming systems (95% confidence interval plots) (N = 27,805 farm households).



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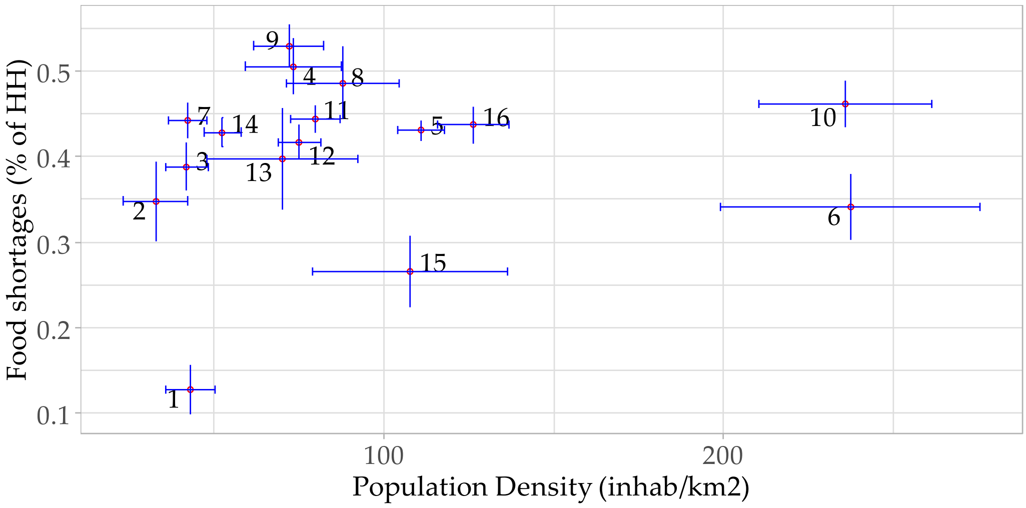

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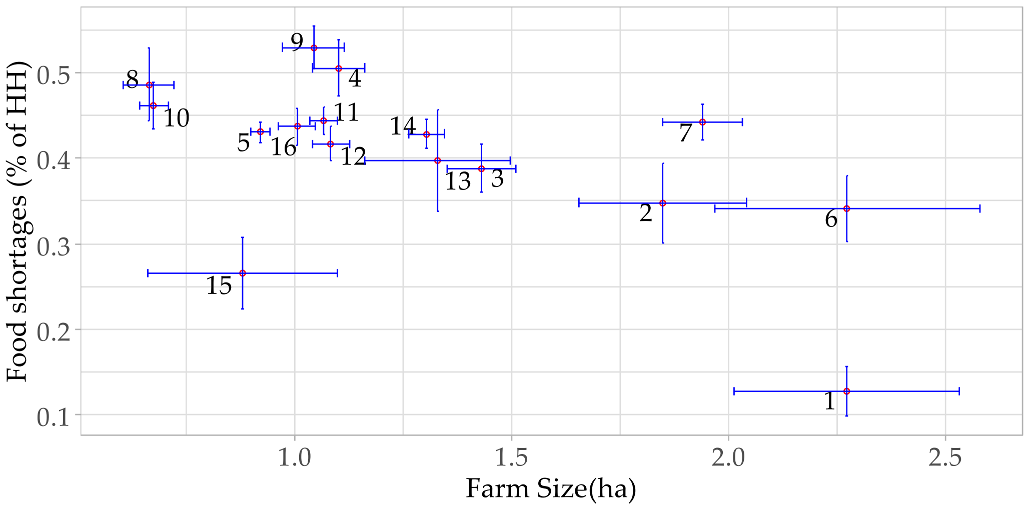


(**c**)

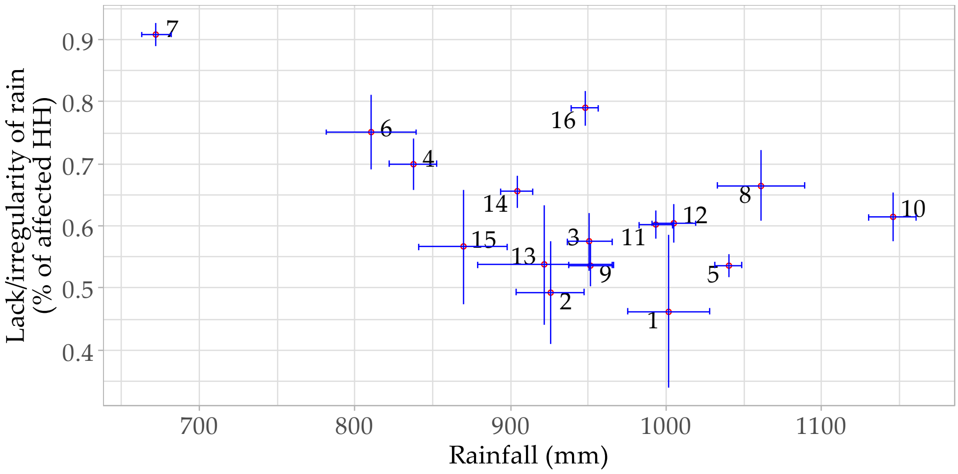
Figure 4. Associations between the likelihood of food shortages (% of farm households) and: (**a**) rainfall (mm); (**b**) population density (inhabitants/km^2); and (**c**) farm size (hectares), across farming system (95% confidence interval plots) (N = 27,805 farm households).

3.1.2. Perceived Causes of Food Shortages and the Drivers of Food Insecurity

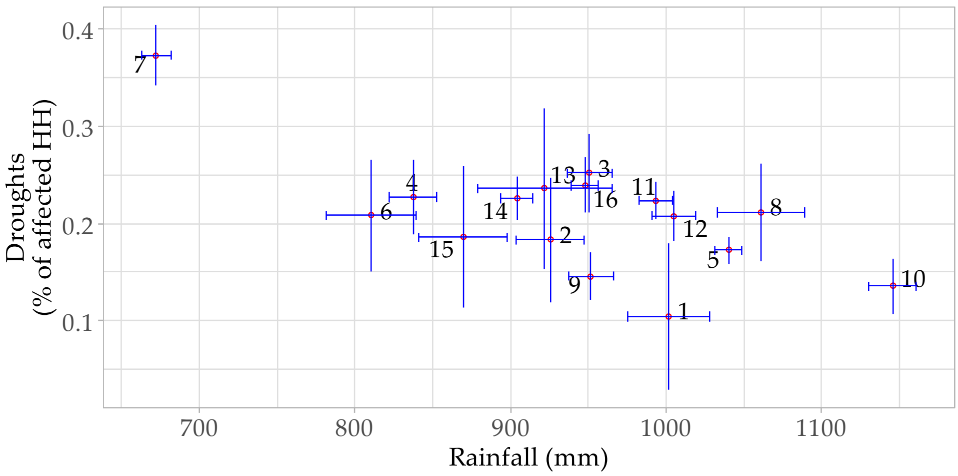
Food insecure farm households, in farming systems predominant in areas with lower rainfall levels, often perceive the lack or irregularity of rain as the main cause of food shortages. For instance, both the lack or irregularity of rain and droughts were perceived by food insecure farm households in FS7—bovine and maize (90% and ~40% of farm households affected by food shortages), as the main causes of food shortages, as most of these food insecure farm households are located in areas with rainfall levels of less than 700 mm (Figure 5a,b).

With FS10 (rice), however, although predominant in humid areas (>1000 mm), about 60% of food insecure farm households in this FS perceived rain as the main cause of food shortages.

There is no clear relationship between the perception of small farmland as a cause of food shortages and population density across farming systems (Figure 5c). On the other hand, food insecure farm households in farming systems with smaller farms (e.g., FS10—rice, FS5—basic food crops, FS8—roots) perceived small farmland as a cause of food shortages (Figure 5d). For farming systems with high use of yield-raising inputs (i.e., FS1—tobacco and FS15—horticultural mixed) smallholders and pests were not perceived as an important factor affecting food shortages (Figure 5e,f). Nevertheless, this was also the case for food insecure farm households in FS7 (bovine) and FS16 (mixed livestock, coconut, and cassava), although they did not use yield-raising inputs.



(**a**)



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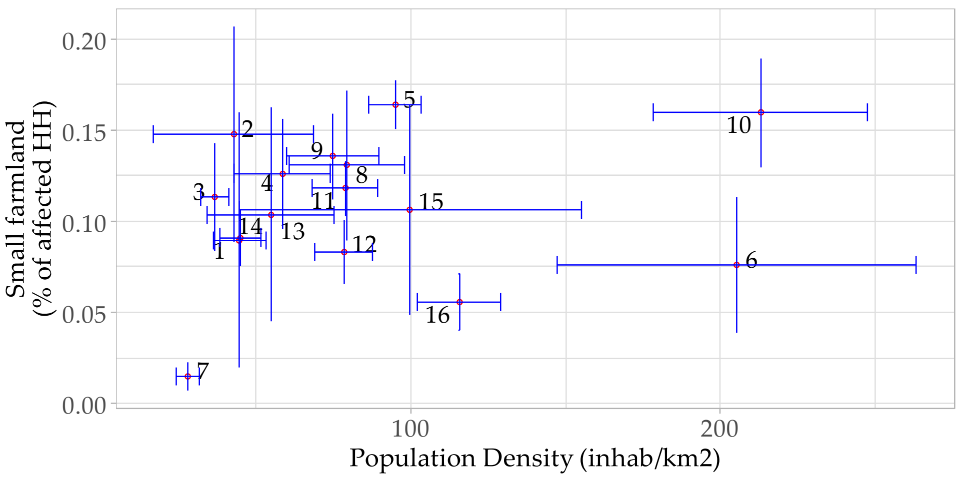

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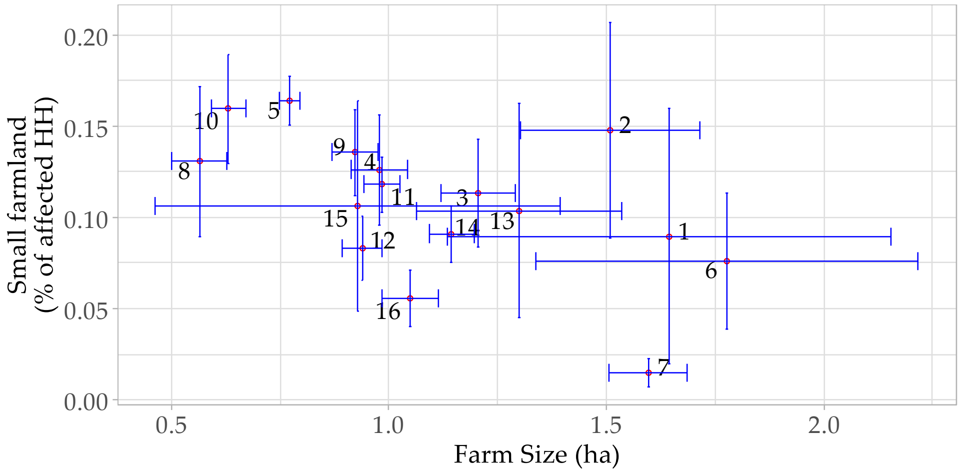

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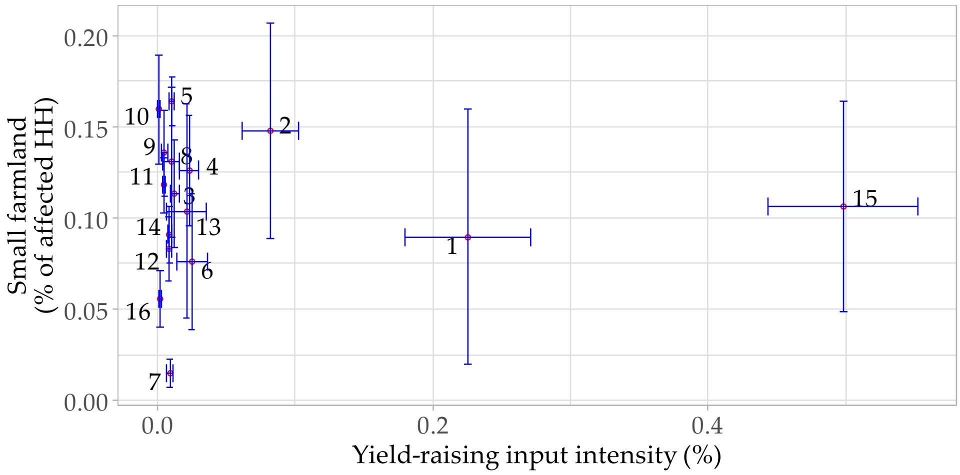

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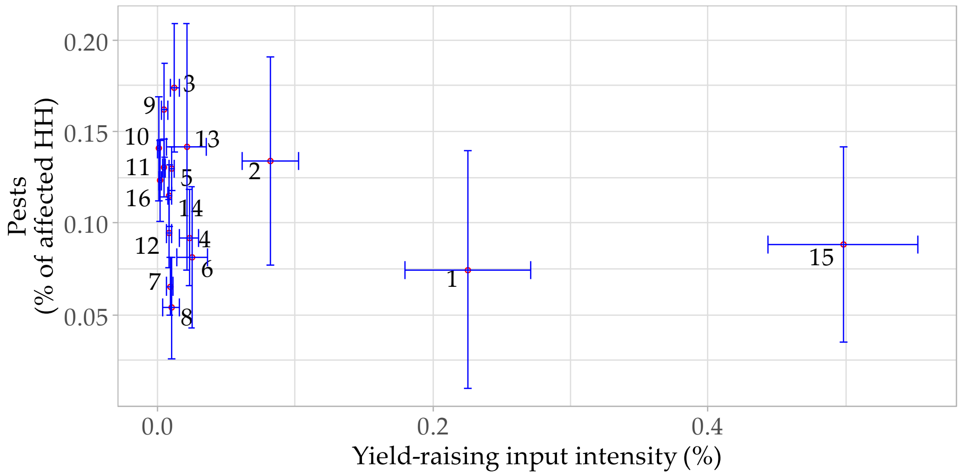
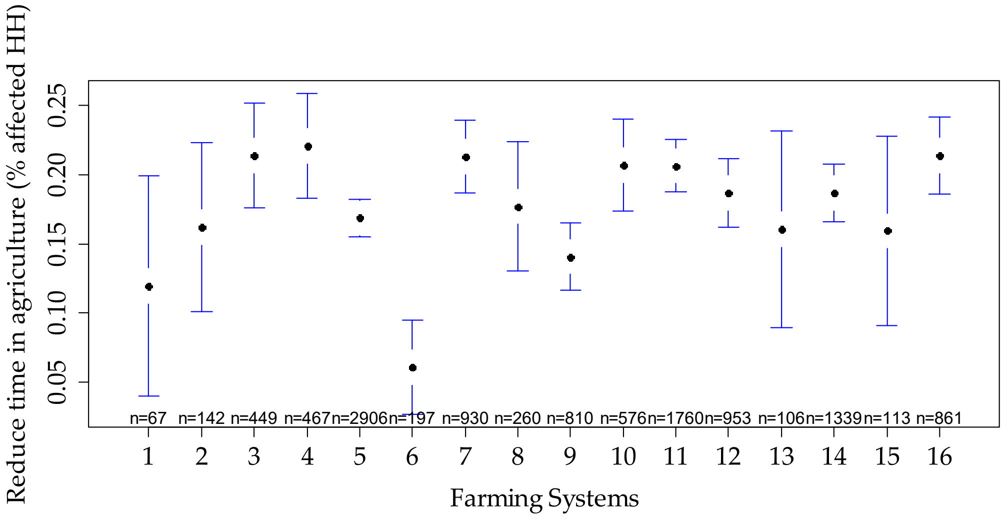


(**f**)

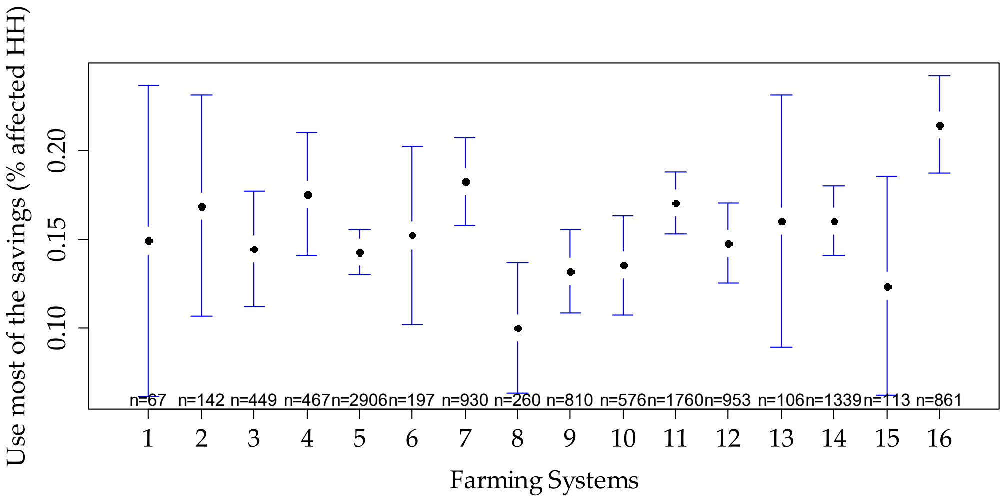
Figure 5. Associations between the perceived causes of food shortages: (**a**) lack of rain; (**b**) droughts; (**c**–**e**) small farmland; and (**f**) pests, and food insecurity drivers, across farming systems (95% confidence interval plots). This information refers only to farm households that reported food shortages (N = 11,936 farm households).

3.1.3. Coping Strategies Adopted by Farmers to Face Food Shortages

To face food shortages, farm households have adopted a set of coping strategies (Figure 6), adopting in some cases more than one strategy, depending on the farming system in which they are integrated. For instance, farm households in FS4 (food crops), when faced with food shortages, prioritized reducing the time dedicated to agriculture and devoting it to other income-generating activities (adopted by 22% of farm households affected by food shortages). Other coping strategies adopted in FS4 include using most of the household savings (18%) and reducing the quality of the diet (16%). Nevertheless, spending most of the household savings is more common among food insecure farm households in FS16 (coconut). FS6 (mixed livestock) rarely adopts any of the strategies, except for spending savings (15% of food insecure farm households). FS13 (sheep and mixed crops) usually resorts to mutual aid with other families to cope with food shortages.



(**a**)



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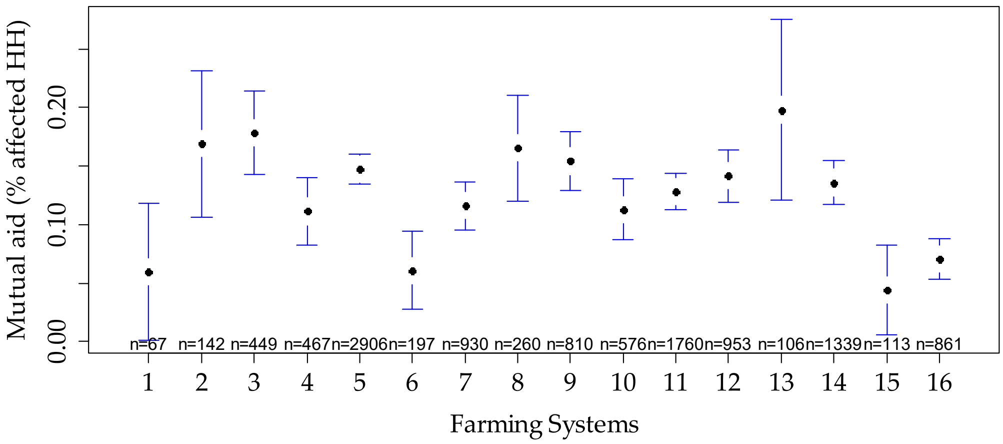

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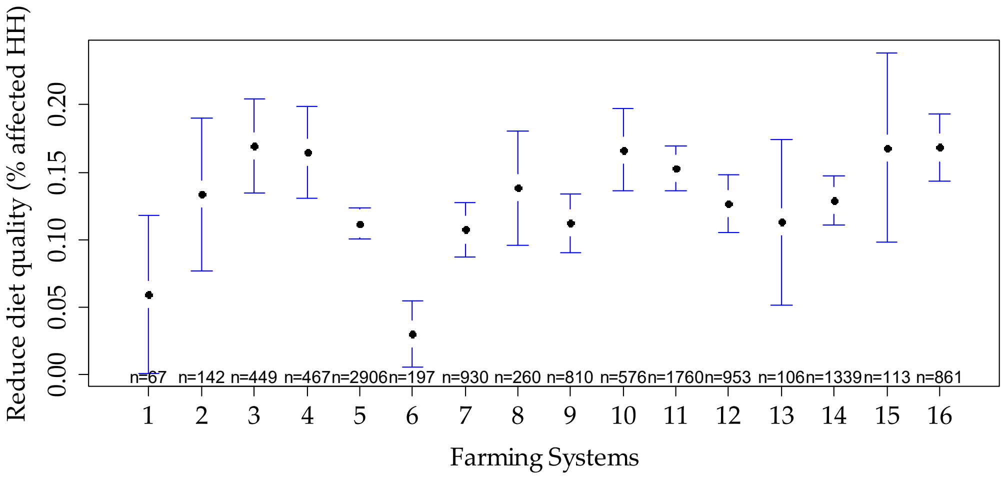

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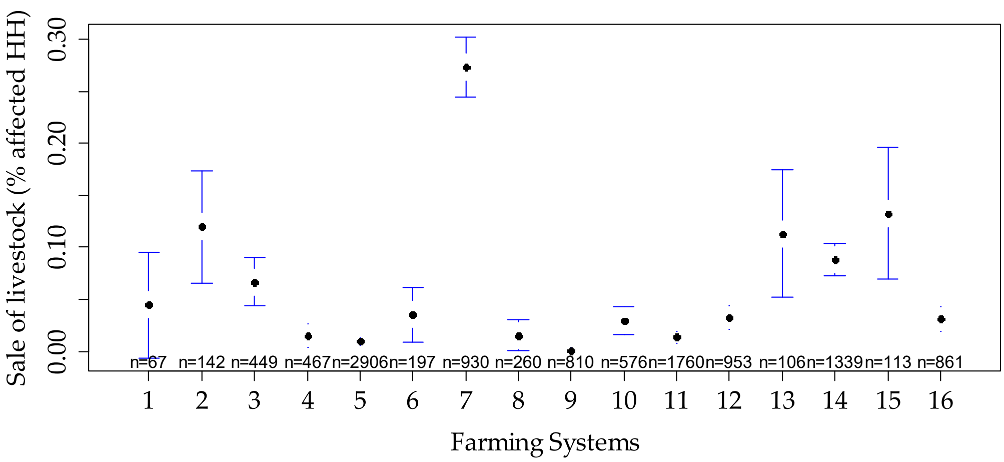
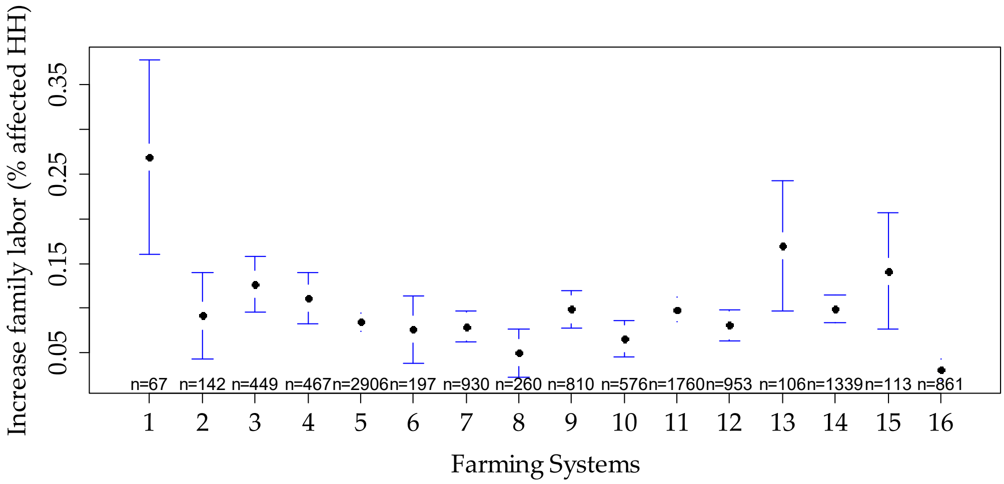


(**e**)

Figure 6. *Cont*.



(**f**)

Figure 6. Strategies adopted by small farmers to alleviate food shortages, based on Agricultural Census 2009–2010 data: (**a**) reduce time dedicated to agricultural activities to devote it to other income-generating activities; (**b**) use of most of the household savings; (**c**) increase mutual aid with other families; (**d**) reduce the quality of the diet; (**e**) sale of large animals; and, (**f**) increase family labor across farming system (95% confidence interval plots). This information refers only to farm households that reported food shortages (N = 11,936), differing from the one in Abbas (2022) [17].

Livestock sale is not a very common strategy among farm households, being predominant in FS7 (bovine and maize). Food insecure farm households in FS1 (tobacco), on the other hand, rely mostly on increasing the use of family labor (strategy adopted by 27%).

4. Discussion

4.1. A Farming System Approach to Explore the Drivers of Food Insecurity

In many developing countries, food insecurity is often seen as a result of inadequate policies [6,7], which have failed to address the major problems faced by most of the population. Persistent poverty has been considered as one of the major causes of food insecurity in many developing countries. Nevertheless, it is important to consider the heterogeneity of the population, in particular among farmers, as they may be affected and could respond differently to the same problem [13,15,16]. A farming system approach has been recognized to provide a relatively simple and practical approach to evaluate agricultural changes and to explore a multitude of issues such as poverty, food security, climate change impacts, among others [3,8,17,23,27], providing useful and powerful insights into strategic priorities for policy intervention, aiming to improve farm households' food security both in the short- and long-term [3,17,47].

Abbas et al. (2023) [8] found a clear association between farming systems and food security levels in Mozambique, which led us to explore, in this paper, the drivers of food insecurity among farm households across farming systems, as well as its relationship with the perceived causes of food shortages by farm households and the corresponding coping strategies adopted.

The results of our analysis showed that highly specialized farming systems are among the most food insecure, while less specialized farming systems are considered more food secure. Many studies found that concentrating production in a few crops and/or livestock may increase vulnerability to production, price, and climatic shocks, with negative effects on food security [48–50]. Whereas farmers, engaged in more diversified systems (e.g., horticultural and/or cash crops, also including food crops and livestock) to meet the household food security needs [51,52], are more resilient to zonal climatic and social perturbations, positively influencing food security [8,49,50]. In addition to the fact that livestock is considered a safety net for many poor farm households, livestock can also provide access to animal traction and organic fertilizers, contributing to higher crop yields; therefore, the absence of livestock may be seen as contributing to food insecurity [15,50].

Nevertheless, it is important to note that specialization alone does not explain food insecurity. We found that market integration, the use of yield-raising and labor-saving inputs are also important factors explaining food insecurity across farming systems—as also verified in Abbas (2022) [17]. Based on the results, farming systems, although moderately specialized, that are to some extent integrated in the market and use either yield-raising or labor-saving inputs, are likely to be food secure. Whereas highly or moderately specialized farming systems that are not integrated in the market, with very low use of yield-raising and labor-saving inputs and with absence of livestock, are most likely food insecure.

For instance, in Mozambique, most of the tobacco and cotton production (represented by FS1(tobacco and maize) and FS2 (cotton)—both considered as food secure farming systems)—is done by small farmers in a subcontracting system [53,54], in which large concessionaire companies buy most of the production directly from the farmers at a fixed price established by the competent institutions [17]. These companies are usually responsible for the supply of yield-raising inputs, credit, and extension services, as well as for transporting, storage, basic processing, and selling [17,53]. The value chain guarantees the supply of inputs and the subsequent purchase of the product, meaning that farm households producing these crops, located close to the areas in which these companies operate, are likely to be integrated in the market with access to agricultural services, which influences positively farmers' income and food security [17].

Additionally, access to roads and proximity to urban areas also facilitate access to markets and off-farm opportunities contributing to increase farmers' income [17,23] while positively driving adoption of more diverse systems [51], contributing positively to food security. Take the case of FS6 (mixed livestock and maize) and FS7 (bovine, maize, and other food crops), both moderately specialized towards livestock (but including food and horticultural crops), with similar market integration levels and labor-saving input intensity (Figure 3b,d). These systems differ mainly regarding their location and the available infrastructure and opportunities. FS6 (mixed livestock), considered food secure, is predominant in the Maputo province (zone 6 in Figure 2)—with good access to developed road networks, formal and informal markets, and off-farm opportunities [17,55,56]; while FS7 (bovine and maize), which is considered food insecure, is located in semi-arid areas mainly in the inland South region (zone 7 in Figure 2), a remote area with less developed roads and markets. During the rainy season, for instance, access to markets in this area is precarious [55], which impacts farm households' livelihoods and food security.

Climate has also been considered an important driver of farming system choice and food insecurity, as agriculture in many developing countries, such as Mozambique, is dependent on rainfall and is extremely vulnerable to variability and changes in rainfall patterns [3,8]. In Sub-Saharan Africa food insecurity has often been associated, among other factors, with droughts [3]. In this study, the lack or irregularity of rain and occurrence of droughts has been perceived by most farm households as the main causes of food shortages. Farming systems prevalent in semi-arid areas, where most livestock-oriented farming systems predominate (e.g., FS7—bovine and maize), and the lack or irregularity of rain and droughts were perceived as the main causes of food shortages by most farm households. According to Dixon et al. (2001) [3], droughts are the main source of vulnerability in agropastoral farming systems in Sub-Saharan Africa, due to crop failure, weak animals, and distress of sale of assets. Farming systems prevalent in humid areas are also vulnerable to lack of rain and droughts, as they are mostly situated in a rainfed system. Therefore, it is expected that any changes or variability in rainfall patterns will likely affect agricultural production and yields [57,58].

Additionally, these food insecure rainfall-dependent farming systems are also predominant in areas with high population density, around 75 inhabitants/km^2—well above the country average of 31 inhabitants/km^2 and the average for the most populated province (Zambézia) of 60 inhabitants/km^2 [59]—putting pressure on available resources, with particular emphasis on the Northern and Central regions, which are also the major food production areas [17]. A demographic trap tends to occur in the most fertile/humid areas which promote population growth through immigration or higher natality rates, until the population density reaches levels when there is not enough land for people, which impacts food security and puts even more pressure on natural resources (this is verified, for instance, in Namuli, Gurué District [60]). Studies have shown that areas with the highest shares of food production, being also densely populated, are also the ones most vulnerable to food insecurity [3,23,61]. This can be related to the difficult access to markets, lack of off-farm work, low monetary incomes [17,61], and competition for land. As confirmed by the results of this study, farming systems with access to developed infrastructures (e.g., roads, markets, irrigation systems—such is the case of FS15—horticultural and mixed livestock and permanent crops and FS6—mixed livestock and maize), although predominant in extremely densely populated areas (between 100 and 230 inhabitants/km^2), are food secure. The opposite is verifiable for farming systems located in heavily dense populated areas, moderately or highly specialized with no access to (inputs and output) markets (which, for instance, is the case of FS10—rice and mixed permanent crops and livestock).

The results confirm that farm size is another important driver of food insecurity, as farming systems with smaller farms (less than 1.5 hectares) are the most food insecure. This is also true in most African countries, where most of the under-nourished people are associated with farming systems where farm sizes are small [9]. However, our results highlighted that farming systems with small farmland that have access to yield-raising (e.g., irrigation, manure, and others) and labor-saving inputs (e.g., animal traction) are more likely to be food secure. This brings attention to the fact that limited access to land does not always lead to food insecurity if other relevant means of production are available and accessible by farm households. Nevertheless, the size of the farm (i.e., small farmland) was perceived by food insecure farm households as a cause of food shortages. Limited access to land is a significant constraint in humid and highly populated areas, which can negatively affect food security. Despite this, the results showed no clear relation between small farmland (as a cause of food shortages) and population density, which can be related with the fact that population density in this study was computed at the administrative post level (a geographic territory, which includes different types of farm households and farming systems), while farm size, for instance, was assessed at the farm-level, and therefore gives a better understanding of the land constraints.

Overall, the factors analyzed (level of specialization, market integration, use of yield-raising and labor-saving inputs, farm size, etc.) are important drivers explaining food insecurity among farm households across farming systems. The analysis also showed that farm households' perceptions regarding the causes of food shortages are related with the drivers of food insecurity.

The farming system approach was revealed to be a suitable procedure for exploring the drivers of food insecurity, as it allowed identification of the specific factors that may contribute to food security, as well as identification of other potential drivers that were not explicitly studied in this paper, such as access to roads (infrastructures) and to off-farm activities/income. This approach enables a contextualized understanding of food insecurity that considers the socioeconomic context and is based on farm household choices and perceptions, providing insights to policymakers as to which instruments can be managed in the short-term to improve food security among farm households in each farming system.

4.2. Exploring Coping Strategies Adopted by Farm Households Across Farming Systems

Exploring the coping strategies adopted by farm households to face food shortages allows the options and the actual choices made by them to be understood, which gives insights on how they behave when faced with food shortages. The results highlighted a clear relation between farming systems and the coping strategies adopted by farm households.

Food insecure farm households in highly specialized farming systems (e.g., FS11—small livestock and mixed crops, FS8—roots and mixed permanent crops, FS4—food crops, FS12—swine and mixed crops, FS5—basic food crops, FS16—mixed livestock, coconut, and cassava) usually tend to reduce the time dedicated to agricultural activity to devote it to other income-generating activities (on average, 21% of farm households in these FSs adopted this strategy). These farming systems are characterized by smaller farms (on avg. 1 ha) and are not integrated in the market, concentrating most of the rural poor population. A study in Central Tanzania also found that poor households usually sell their own labor and perform several farm and non-farm activities, regardless of the season, to cope with food insecurity [18]. Many studies have found the same set of coping strategies being adopted by farmers in developing countries [3,23,62–64]. A study developed in Zambézia province, in Mozambique, also confirmed that engaging in on and/or off-farm seasonal work (also referred as *ganho-ganho*—which can also include working for food) is a common strategy adopted by small farmers to face food shortages, being adopted mostly by farmers in less diversified farming systems [65].

In this study, we found that farm households, integrated in the farming system predominant in proximity with urban and peri-urban areas (i.e., FS6—mixed livestock and maize), usually do not adopt any strategy when faced with food shortages, with only 15% of food insecure farm households spending most of the savings to face food shortages. This system is moderately specialized (with food and horticultural crops and a diversity of livestock); it is also one of the FSs with high use of labor-saving inputs (tractors and bovine traction) and has large farms (on avg., 2.3 ha). It is one of the systems with the largest number of household members (7) and is predominant in areas close to urban or peri-urban settings; therefore, household members are expected to be already engaged in off-farm activities.

On the other hand, moderately specialized farming systems, that are only slightly integrated in the market, usually use most of their savings to face food shortages; while market-oriented farming systems, which are expected to have better savings, tend to resort less to this strategy. Farms in these less market-integrated farming systems are usually managed by women (30–50%), which might give them more ownership over the money; while the market-oriented farming systems include farm households and farms both headed and managed mostly by men (around 80–90%). It is also important to consider that farm households, practicing farming systems that are more integrated into the market, are expected to be more endowed than the ones in less market-oriented systems. Earnings in these systems might be invested back in the farm. Commercial orientation in farming creates motivation and resources to invest and increase productivity for most farming systems dependent on farm-income [13,16]. Farm households in these market-oriented systems tend both to reduce the quality of their diet, i.e., reduce the consumption of meat, fish, and vegetables (which is the case for 17% of food insecure farm households in FS15—horticultural and mixed livestock as well as permanent crops and FS3—sesame and maize), or to increase family labor (adopted by almost 30% of food insecure farm households in FS1—tobacco and maize); these are considered less severe coping strategies [12]. It is important to note that farm households in these systems tend to be more endowed, therefore, they have a larger set of available options to cope with food shortages. Less endowed farm households might be already living in a situation of stress, in which less diversified diets are adopted and most family labor is already employed on the farms; therefore, they rely on their savings to cope with food shortages.

The sale of large livestock (e.g., cattle, goats, and pigs) as a strategy to face food shortage is not very common among farm households, being prevalent in livestock-oriented farming systems predominant in arid areas (adopted by 27% of food insecure farm households in FS7—bovine and maize). Other coping strategies adopted by farm households in FS7 are the increase of off-farm activities, use of savings, and reducing the quality of the diet. Other studies also found similar coping mechanisms in agropastoral systems in other African countries [3]. In many African countries, livestock has a cultural and social role in the communities, representing wealth and a safety net or buffer against extreme shocks [15]; however, households may avoid selling large livestock to face food shortage in the short run. Rather than immediately selling livestock to overcome food shortages, farm households first try to employ other means of generating income or finding food, such as seeking for food loans or off-farm and/or casual labor [18,23]. In this study, we found that not all livestock-oriented farming systems sell large livestock to face food shortages. Livestock-oriented farming systems managed mostly by men (on avg. 70%) usually resort more to selling livestock as a coping strategy, whereas farming systems, including large livestock, whereas in the farms that are managed by women predominately (c.a. 50% are managed by women), this strategy is rarely adopted. Gender inequality is an important factor to consider in many African countries; even though women are responsible for most agricultural activities and food consumed by the household members, they have limited ownership, control, and access to assets that can be exchanged for food, i.e., livestock, which also makes female-headed households more likely to be food insecure [23].

4.3. Contributing to Policy Design in Targeting Food Insecure Farm Households in Developing Countries

Food insecurity is largely considered a rural phenomenon, affecting mostly farm households in developing countries [3]. Farm households in less diversified and endowed farming systems are the most vulnerable to food insecurity, as shown by the results in this study. The same is also observed in other developing countries [3]. Biophysical drivers, such as climate (e.g., rainfall), have a great influence on farming system choice [8], being also an important source of vulnerability for most farming systems [57,58,66], leading to crop failure and food shortages, as perceived by most farm households, both in semi-arid and humid regions.

Nevertheless, farm households' vulnerability to food insecurity goes beyond climate shocks, being also influenced by socioeconomic drivers, which frame the options available to farmers and reveal the important role of public policies in reducing farm households' vulnerability to food insecurity in developing countries [17]. For instance, humid areas, which are the most fertile and productive areas, concentrate most food insecure farming systems, mostly related with the fact that these are also highly populated areas, which puts pressure on access to resources (e.g., land). Most systems in these areas are highly or moderately specialized (focused mainly on staple food crops) with limited access to markets and yield-raising and labor-saving inputs, as well as limited access to financial resources, i.e., farm and/or off-farm income and credit, being considered more vulnerable to food insecurity and external shocks (e.g., climatic, prices). Market integration and access to yield-raising and labor-saving inputs have been shown to have a positive effect on food security and can be managed through public policies [3,13,23,67].

The coping strategies adopted by farm households are directly related to the type of farming system in which they are inserted. Most farming systems specialized in food crops reduce the time in agriculture and the quality of their diet to cope with food shortages. This highlights the need to support diversification within the farming system and to create opportunities that allow the diversity of income sources (promotion of off-farm activities) [68]. Farming system and livelihood diversity will allow farm households to diversify income sources and engage in yield-raising and labor-saving techniques which would lead to improvements in crop yields. This can stimulate labor productivity and farm income if appropriate infrastructure is available, e.g., roads, storage, and conservation facilities, allowing the integration of farmers in the market, contributing to reduce farmers vulnerability to both food insecurity and external shocks (such as climate or price rises) [17,68,69]. In addition to creating a safety net for farmers, the promotion of off-farm opportunities will allow the population to disperse to other areas, reducing pressure on resources (e.g., land). Nevertheless, it is important that the basic public services are created (such as, education, health facilities and services, infrastructures–roads, etc.) [68,70].

The study findings also reinforce the need to integrate livestock, as these have a positive effect on the adoption of labor-saving inputs, which then contributes to increase yields and also constitutes a safety net in periods of shortages [23,68]. Nevertheless, public policies should also enhance gender access and control over land and livestock assets [23].

Overall, it is important to promote better access to markets, yield-raising and labor-saving inputs, and infrastructures (that support the development of agriculture and other activities), as well as to give stimuli to farm diversification to reduce farm households' risks. The greater the incentives for diversification as well as food value-chain development, the greater is the farm households' capacity to reduce food insecurity. Public policies have a leading and crucial role in making this happen. If adequate policies are implemented, even in the event of external shocks (e.g., climatic), farm households would be able to cope with food shortages and food insecurity.

5. Conclusions

The farming system approach enabled appreciation of the logic behind farm households' adopted strategies; that is, it introduced another layer of comprehension that would not be possible by analyzing only the general means and standard deviation of the variables. This gives a better understanding of the choices available to farm households in each farming system. A grounded knowledge of food security in the local/regional context (i.e., considering the diversity of farming systems) contributes to better understanding on how people manage their food livelihoods, exercise food choices, and expose some of the socio-economic drivers underlying food insecurity, which can then be leveraged by policymakers seeking to improve food security in the short- and medium-term.

Vulnerability to food insecurity, either perceived by farm households or based on the analysis of the drivers, is related to both descriptors—market integration and use of yield-raising and labor-saving inputs—and drivers—climate (rainfall), population density and farm size, of farming system choice. Although most farming systems are predominant in regions that, in theory, would promote more food security—due to its agricultural potential—the high population density and limited access to land and other resources tend to exacerbate situations of food insecurity. This is aggravated by the fact that these are specialized staple food systems, with limited access to markets and infrastructures, which limits the set of coping strategies that can be adopted by each farmer in each farming system.

In this sense, this approach allows policy makers to tailor policy design to specific farming systems, as no one-policy intervention fits all farm households. Our results support the idea that designing more effective policy requires understanding the heterogeneity of farm households, their farming systems, as well as the factors affecting food insecurity patterns and the corresponding coping strategies.

The use of an agricultural census database to access food insecurity data—which was also used to derive the farming system typology—provides a simpler and easily attainable tool to access farm-level data that can be used by governments, policymakers, research institutions, and other actors for policy analysis or to explore and understand a range of issues affecting farm households in developing countries, contributing to improving food security among the most vulnerable.

Finally, some limitations were identified related with the fact that other important factors affecting food insecurity, such as access to off-farm income as well as roads and other relevant infrastructure, were not explicitly analyzed, which was mostly due to lack of data in the census data we used in this paper. In future analysis we will combine census data with other sources including primary data collection to expand our analysis to these other possible drivers. Our approach to explore the drivers of food insecurity is framed in a farming system approach, in particular, in making cross-section comparisons between farming systems. Therefore, it misses other aspects of food insecurity related with historical processes like the growing rural population without many livelihood alternatives to farming. These aspects would require a different approach and different data (time series).

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visualization, M.A.; supervision, P.F.R. and J.L.S.; project administration, M.A.; funding acquisition, M.A., P.F.R. and J.L.S. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The datasets generated and analyzed in this paper are available upon reasonable request to the corresponding author.

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Appendix A

Table A1. Summary of the variables considered for the classification of farms by FS (N = 27,805) [8].

Variables		Description (Crops/Livestock)
Land use/cover	Annual Crops (proportion of total arable area)	Maize
		Rice
		Sorghum+ (includes Millet)
		Cassava
		Sweet Potato
		Cowpea
		Beans
		Groundnut
		Sesame
		Cotton
		Tobacco
		Hort1 (Pumpkin, Watermelon and Okra)
		Hort2 (Tomato, Kale, Onion, Potato, Lettuce, and Cabbage)
		Hort3 (Cucumber, Yam, Green beans, Garlic, Carrot, Pepper, and Eggplant)
		Other annual crops (e.g., peas, sunflower, soy, sugarcane, wheat, ginger)
	Permanent Crops (PERM) (proportion of total fruit tree stems)	Mango
		Cashew
		Coconut
		Citrus (Orange, Lemon, Tangerine, and Grapefruit)
		Other Fruits (Papaya, *Maçanica*, *Mafurra*, Guava, Avocado, *Jambalão*, Peach, Litchi, and Apple)
	Proportion of equivalent arable area with permanent crops	

Table A1. *Cont.*

Variables		Description (Crops/Livestock)
Livestock Variables	Livestock (proportion in total standard livestock units)	Bovine
		Goats
		Swine
		Small Livestock (Chickens, Ducks, Bush chicken, Turkeys, Rabbits, and Geese)
		Sheep
	Livestock density (number of standard livestock units per hectare of arable area)	
Output Diversification	Gross Product (proportion of total output, i.e., Total Gross Product—TGP [(a)])	Annual Basic Food Crops (STAPLES)
		Horticultural Crops (HORT)
		Cash Crops (CASH)
		Cashew
		Coconut
		Livestock
	Economic Intensity [output (MZN) per hectare of arable area]	
Yield-raising input intensity (proportion of arable area)		Irrigation
		Pesticide
		Fertilizer
		Manure
Labor and labor-saving inputs	Labor productivity—output (MZN) per labor unit [(b)]	
	Labor intensity—labor units per hectare of arable area	
	Bovine traction use: 1—yes; 0—otherwise	
	Tractors use indicator: 1—yes; 0—otherwise	

Note: [(a)] TGP refers to the total output of the farm, including crops (annual and permanent) and livestock. [(b)] Labor units correspond to the sum of all units of labor employed in agriculture and livestock activity, including the following: (i) family labor (weighted in 100% for those who had agricultural as their main activity, and 25% as their secondary activity); (ii) full-time workers (assumed to dedicate 100% of their time to agricultural activity); and (iii) temporary workers (assumed to spend 10% of their time). Source: Abbas (2022) [17] and Abbas et al. (2023) [8].

Table A2. Aggrupation of farming systems by zones (% of the Total Agricultural Area—TAA) [8].

ZONES	FS1	FS2	FS3	FS4	FS5	FS6	FS7	FS8	FS9	FS10	FS11	FS12	FS13	FS14	FS15	FS16
1	0.024	0.005	0.040	0.020	0.402	0.020	0.012	0.017	0.043	0.028	0.183	0.084	0.011	0.088	0.012	0.011
2	0.000	0.015	0.044	0.014	0.183	0.007	0.021	0.005	0.175	0.024	0.158	0.082	0.026	0.229	0.002	0.015
3	0.644	0.003	0.023	0.008	0.071	0.019	0.040	0.000	0.000	0.000	0.043	0.064	0.005	0.058	0.022	0.000
4	0.005	0.096	0.174	0.057	0.166	0.017	0.011	0.007	0.027	0.024	0.157	0.095	0.009	0.152	0.002	0.002
5	0.017	0.039	0.043	0.099	0.112	0.024	0.237	0.006	0.016	0.018	0.105	0.069	0.004	0.177	0.010	0.025
6	0.000	0.001	0.013	0.019	0.181	0.301	0.071	0.061	0.042	0.000	0.090	0.039	0.003	0.085	0.068	0.026
7	0.006	0.009	0.011	0.030	0.070	0.076	0.535	0.003	0.046	0.000	0.072	0.020	0.017	0.080	0.017	0.008
8	0.011	0.000	0.037	0.013	0.269	0.025	0.001	0.063	0.028	0.272	0.135	0.020	0.005	0.028	0.004	0.089
9	0.000	0.007	0.001	0.003	0.047	0.004	0.028	0.008	0.011	0.003	0.088	0.122	0.003	0.035	0.008	0.632

Source: Abbas et al. (2023) [8].

Table A3. Computation of the drivers of food insecurity.

Variable	Description	Formula	Var. Code	Name of the Variable to Extract	Source of Data
Specialization		MAX (WGP_g)	WGP_g	Weight of crop group or livestock type *g* in Total Gross Product	2009–2010 Agricultural Census
Market Integration	Proportion of sales in total output (%)	(TSale/TGP)*100	TSale	Total farm sales (MZN): TSale = CropSale + LivSale	
				CropSale—total farm crop sales	
				LivSale—total livestock sales	
			TGP	Total Gross Product (MZN): TGP = GPC + GPLiv	
				GPC—Total Crop GP	
				GPLiv—Total Livestock GP	
Yield-raising input intensity		AVERAGE ($WYInput_i$)	$WYInput_i$	Proportion of arable area using yield-raising input *i* (*i* = pesticides, fertilizers, manure, and irrigation)	
Labor-saving input intensity		AVERAGE ($LBSavInput_j$)	$LBSavInput_j$	Use of labor-saving inputs *j* (*j* = animal traction, plows, tractors, etc.)	
Rainfall	Average annual rainfall (mm)	Σ pr (i)	pr (i)	Rainfall of month i (i = 1, . . ., 12) (mm)	WorldClim (average period 1970–2000)
Farm size	Farm size (ha)	FArea	FArea	Farm area (all parcels) (ha)	2009–2010 Agricultural Census

Table A3. *Cont.*

Variable	Description	Formula	Var. Code	Name of the Variable to Extract	Source of Data
Population Density	Population density (inhabitants/km^2)	POP/APA	POP	Population by administrative post (inhabitants)	National Statistical Institute
			APA	Administrative post area (km^2)	

Table A4. Descriptives statistics of the variables considered in the analysis.

Variable	Description	Mean	SD
Food Shortage	The farm household experienced food shortages (1—yes, 0—no)	0.43	0.49
Drivers			
Specialization	Maximum contribution of a specific crop or livestock group for the total output (%)	0.79	0.22
Market Integration	Proportion of sales in total output (%)	0.09	0.19
Yield-raising inputs	Proportion of the farmland that uses yield-raising inputs (%)	0.02	0.09
Labor-saving inputs	Proportion of labor-saving inputs used, considering the set of available labor-saving inputs (%)	0.07	0.14
Population density	Population density (inhabitants/km^2)	91	246
Rainfall	Average annual rainfall (mm)	995	231
Farm size	Farm size (ha)	1.2	1.4
Perceived causes of food shortages (1–yes, 0–no)			
Cause_LackRain	Lack or irregularity of rain	0.27	0.44
Cause_Droughts	Droughts	0.09	0.29
Cause_Pests	Pests	0.05	0.22
Cause_SmallFarmland	Small farmland	0.05	0.22
Strategies to alleviate food shortages (1–yes, 0–no)			
Strat_ReducedAgricActiv	Reduce the time spent practicing agricultural activities to dedicate it to other activities	0.08	0.27
Strat_Savings	Use most of the household savings	0.07	0.25
Strat_MutualAid	Increase the practice of mutual aid with other families	0.06	0.23
Strat_DietQuality	Significantly reduce the quality of the diet	0.06	0.23
Strat_LivestockSale	Sale of large animals such as cattle, goats and pigs	0.02	0.14
Strat_FamilyLabor	Increase family labor in the farm	0.04	0.19

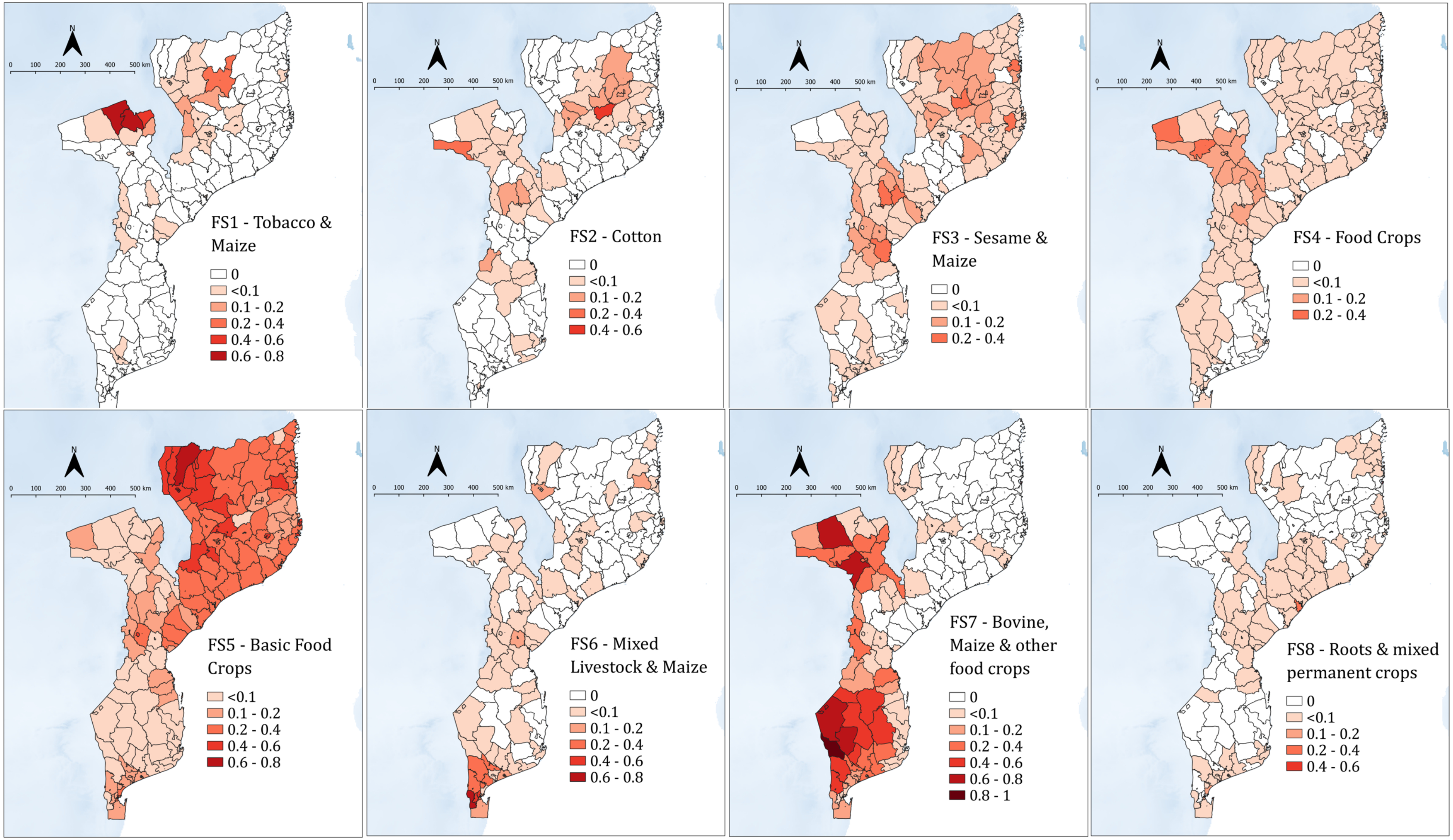

Figure A1. *Cont.*

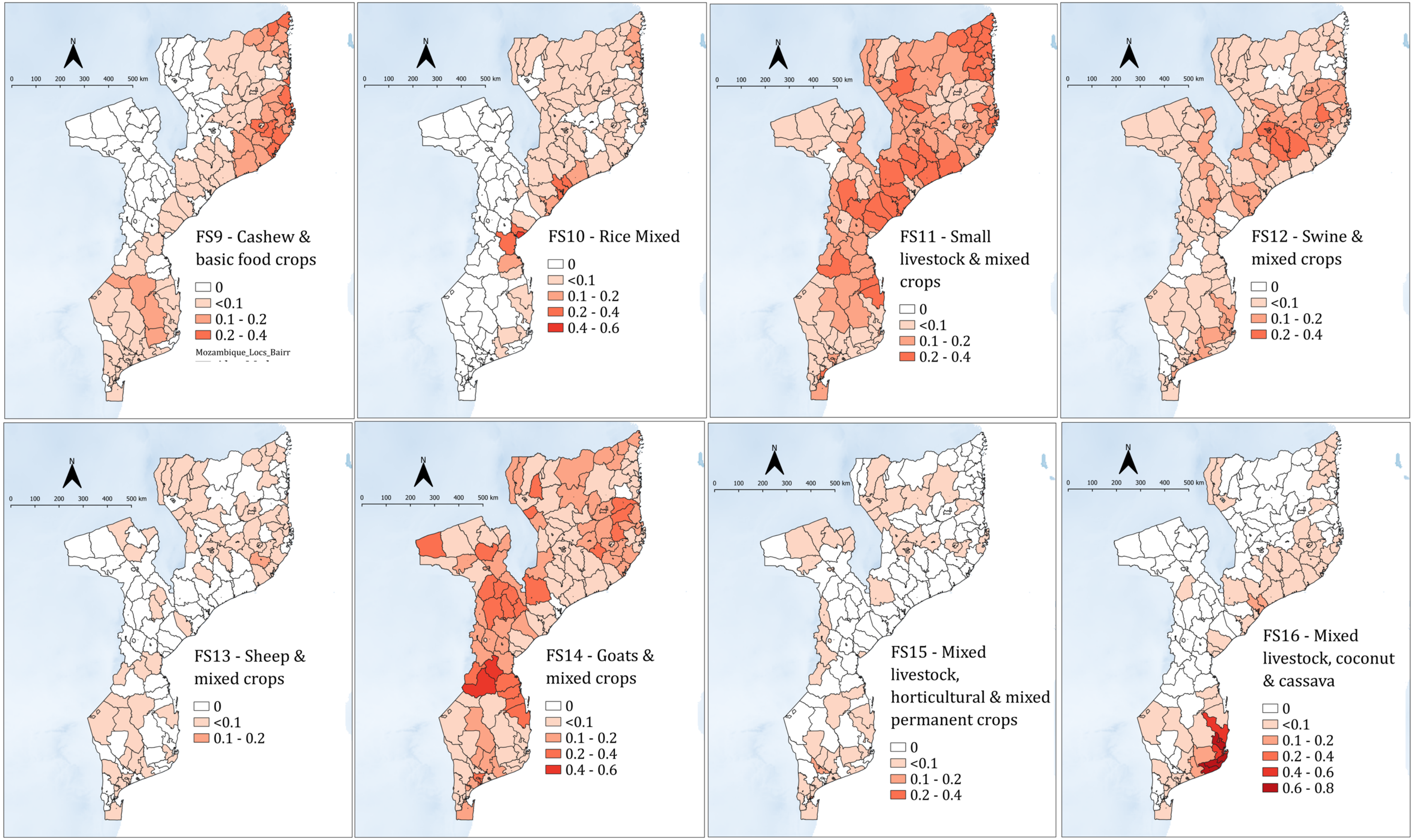

Figure A1. Spatial distribution of farming systems in Mozambique. Source: Abbas et al. (2023) [8].

References

1. Von Grebmer, K.; Bernstein, J.; Resnick, D.; Wiemers, M.; Reiner, L.; Bachmeier, M.; Hanano, A.; Towey, O.; Chéilleachair, R.N.; Foley, C.; et al. *Global Hunger Index: Food Systems Transformation and Local Governance*; Welthungerhilfe: Bonn, Germany; Concern Worldwide: Dublin, Ireland, 2022; ISBN 978-1-9161928-9-8.
2. FAO; IFAD; UNICEF; WFP; WHO. *The State of Food Security and Nutrition in the World 2024—Financing to End Hunger, Food Insecurity and Malnutrition in All Its Forms*; FAO: Rome, Italy; IFAD: Rome, Italy; UNICEF: New York, NY, USA; WFP: Rome, Italy; WHO: Geneva, Switzerland, 2024.
3. Dixon, J.; Gulliver, A.; Gibbon, D. *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World*; Hall, M., Ed.; FAO: Rome, Italy; World Bank: Washington, DC, USA, 2001.
4. Ford, J.; Berrang-Ford, L.; Bunce, A.; Mckay, C.; Irwin, M.; Pearce, T. The Status of Climate Change Adaptation in Africa and Asia. *Reg. Environ. Chang.* **2015**, *15*, 801–814. [CrossRef]
5. University of Notre Damme Notre Dame Global Adaptation Initiative: Country Index. Available online: https://gain.nd.edu/our-work/country-index/rankings/ (accessed on 26 January 2024).
6. Sen, A. *Food, Economics and Entitlements*; World Institute for Development Economics Research: Helsinki, Finland, 1986.
7. Hoeffler, H. The Political Economy of Agricultural Policies in Africa: History, Analytical Concepts and Implications for Development Cooperation. *Q. J. Int. Agric.* **2011**, *50*, 29–53.
8. Abbas, M.; Ribeiro, P.F.; Santos, J.L. Farming System Change under Different Climate Scenarios and Its Impact on Food Security: An Analytical Framework to Inform Adaptation Policy in Developing Countries. *Mitig. Adapt. Strateg. Glob Chang.* **2023**, *28*, 43. [CrossRef]
9. Garrity, D.; Dixon, J.; Boffa, J.-M. Understanding African Farming Systems: Science and Policy Implications. In Proceedings of the Food Security in Africa: Bridging Research and Practice, Sydney, Australia, 29–30 November 2012.
10. Misselhorn, A.A. What Drives Food Insecurity in Southern Africa? A Meta-Analysis of Household Economy Studies. *Glob. Environ. Chang.* **2005**, *15*, 33–43. [CrossRef]
11. Mkandawire, P.; Aguda, N.D. Characteristics and Determinants of Food Insecurity in Sub-Saharan Africa. In *Environment and Health in Sub-Saharan Africa: Managing an Emerging Crisis*; Springer: Dordrecht, The Netherlands; Berlin/Heidelberg, Germany; London, UK; New York, NY, USA, 2009; pp. 3–23. ISBN 978-1-4020-9381-4.
12. Chagomoka, T.; Unger, S.; Drescher, A.; Glaser, R.; Marschner, B.; Schlesinger, J. Food Coping Strategies in Northern Ghana. A Socio-Spatial Analysis along the Urban–Rural Continuum. *Agric. Food Secur.* **2016**, *5*, 4. [CrossRef]
13. Kansiime, M.K.; van Asten, P.; Sneyers, K. Farm Diversity and Resource Use Efficiency: Targeting Agricultural Policy Interventions in East Africa Farming Systems. *NJAS—Wageningen. J. Life Sci.* **2018**, *85*, 32–41. [CrossRef]
14. Mascarenhas, A.; Odero-Ogwel, L.A.; Masakhalia, Y.F.O.; Biswas, A.K. Land Use Policies and Farming Systems: Kenya, Tanzania, Zambia and Mozambique. *Land Use Policy* **1986**, *3*, 286–303. [CrossRef]
15. Kuivanen, K.S.; Alvarez, S.; Michalscheck, M.; Adjei-Nsiah, S.; Descheemaeker, K.; Mellon-Bedi, S.; Groot, J.C.J. Characterising the Diversity of Smallholder Farming Systems and Their Constraints and Opportunities for Innovation: A Case Study from the Northern Region, Ghana. *NJAS—Wageningen. J. Life Sci.* **2016**, *78*, 153–166. [CrossRef]
16. Tittonell, P.; Muriuki, A.; Shepherd, K.D.; Mugendi, D.; Kaizzi, K.C.; Okeyo, J.; Verchot, L.; Coe, R.; Vanlauwe, B. The Diversity of Rural Livelihoods and Their Influence on Soil Fertility in Agricultural Systems of East Africa—A Typology of Smallholder Farms. *Agric. Syst.* **2010**, *103*, 83–97. [CrossRef]
17. Abbas, M. A Farming System Approach to Support Food Policies under Climate Change in Developing Countries: The Case of Mozambique. Ph.D. Thesis, Lisbon University, Lisbon, Portugal, 2022.
18. Liwenga, E. Food Insecurity and Coping Strategies in Semiarid Areas: The Case of Mvimu in Central Tanzania. Ph.D. Thesis, Stockholm University, Stockholm, Sweden, 2003.
19. Maxwell, D.; Caldwell, R.; Langworthy, M. Measuring Food Insecurity: Can an Indicator Based on Localized Coping Behaviors Be Used to Compare across Contexts? *Food Policy* **2008**, *33*, 533–540. [CrossRef]
20. Norman, D.W.; Worman, F.D.; Siebert, J.D.; Modiakgotla, E. *The Farming Systems Approach to Development and Appropriate Technology Generation*; FAO, Ed.; FAO: Rome, Italy, 1995; ISBN 9251036446.
21. Köbrich, C. The Construction and Use of Compromise Programming Models to Measure the Impact of Development Policies on the Sustainability of Peasant Farming Systems in Central Chile. Ph.D. Thesis, The University of Reading, Reading, UK, 1997.
22. Boere, E.; Aline, M.; Bocquého, G.; Garbero, A.; Krisztin, T.; Havlik, P.; Elhaut, T. *Developing Country-Wide Farming System Typologies*; International Fund for Agricultural Development (IFAD): Rome, Italy, 2018; ISBN 9789290728566.
23. Massawe, G.D. Farming Systems and Household Food Security in Tanzania: The Case of Mvomero and Kishapu Districts. Ph.D. Thesis, University College Dublin, Dublin, Ireland, 2016.
24. Mnenwa, R.; Maliti, E. *A Comparative Analysis of Poverty Incidence in Farming Systems of Tanzania*; Research on Poverty Alleviation (REPOA): Dar es Salaam, Tanzania, 2010.
25. Thornton, P.K.; van de Steeg, J.; Notenbaert, A.; Herrero, M. The Impacts of Climate Change on Livestock and Livestock Systems in Developing Countries: A Review of What We Know and What We Need to Know. *Agric. Syst.* **2009**, *101*, 113–127. [CrossRef]
26. Thornton, P.; Jones, P.; Alagarswamy, G.; Andresen, J.; Herrero, M. Adapting to Climate Change: Agricultural System and Household Impacts in East Africa. *Agric. Syst.* **2010**, *103*, 73–82. [CrossRef]

27. Ribeiro, P.F.; Santos, J.L. Exploring the Effects of Climate Change on Farming System Choice: A Farm-Level Space-for-Time Approach. *Land* **2023**, *12*, 2113. [CrossRef]
28. Tittonell, P.; Bruzzone, O.; Solano-Hernández, A.; López-Ridaura, S.; Easdale, M.H. Functional Farm Household Typologies through Archetypal Responses to Disturbances. *Agric. Syst.* **2020**, *178*, 102714. [CrossRef]
29. Santos, J.L.; Moreira, F.; Ribeiro, P.F.; Canadas, M.J.; Novais, A.; Lomba, A. A Farming Systems Approach to Linking Agricultural Policies with Biodiversity and Ecosystem Services. *Front. Ecol. Environ.* **2021**, *19*, 168–175. [CrossRef]
30. Mbanze, A.A.; Viera da Silva, C.; Ribeiro, N.S.; Silva, J.F.; Santos, J.L. A Livelihood and Farming System Approach for Effective Conservation Policies in Protected Areas of Developing Countries: The Case Study of the Niassa National Reserve in Mozambique. *Land Use Policy* **2020**, *99*, 105056. [CrossRef]
31. MEF. *Estratégia Nacional de Desenvolvimento (ENDE) 2025–2040*; Ministério da Economia e Finanças: Maputo, Mozambique, 2024.
32. MINAG. *Plano Estratégico Para o Desenvolvimento Do Sector Agrário: PEDSA 2011–2020*; Ministry of Agriculture: Maputo, Mozambique, 2010.
33. INE. *Censo Agro-Pecuário 2009–2010: Resultados Definitivos—Moçambique*; Instituto Nacional de Estatistica: Maputo, Mozambique, 2011.
34. MASA. *Anuário de Estatísticas Agrárias 2015*; Ministry of Agriculture and Food Security: Maputo, Moçambique, 2016.
35. World Bank. *Mozambique: Analysis of Public Expenditure in Agriculture*; World Bank: Washington, DC, USA, 2011; Volume I.
36. Mosca, J.; Nova, Y. *Agricultura: Assim, Não é Possível Reduzir a Pobreza Em Moçambique*; Observador Rural: Maputo, Mozambique, 2019.
37. SETSAN. *Relatório de Estudo de Base de Segurança Alimentar e Nutricional Em 2013 Em Moçambique*; SETSAN: Maputo, Mozambique, 2014.
38. IPC. *Análise IPC Da InsegurançaAlimentar Aguda: Novembro 2021–Setembro 2022*; IPC: Maputo, Mozambique, 2021.
39. Abbas, M. *Segurança Alimentar Pós-Colheita 2022: 50% Da População Em Situação de Insegurança Alimentar Aguda?* Destaque Rural; Observatório do Meio Rural: Maputo, Mozambique, 2023.
40. INE. *Relatório Final Do Inquérito Sobre Orçamento Familiar—IOF 2022*; Instituto Nacional de Estatistica: Maputo, Mozambique, 2023.
41. Andersen, E.; Elbersen, B.; Godeschalk, F.; Verhoog, D. Farm Management Indicators and Farm Typologies as a Basis for Assessments in a Changing Policy Environment. *J. Environ. Manag.* **2007**, *82*, 353–362. [CrossRef]
42. Fick, S.E.; Hijmans, R.J. WorldClim 2: New 1km Spatial Resolution Climate Surfaces for Global Land Areas. *Int. J. Climatol.* **2017**, *37*, 4302–4315. [CrossRef]
43. Dedehouanou, S.F.A.; McPeak, J. Diversify More or Less? Household Income Generation Strategies and Food Security in Rural Nigeria. *J. Dev. Stud.* **2020**, *56*, 560–577. [CrossRef]
44. Meertens, H.C.C.; Fresco, L.O.; Stoop, W.A. Agriculture Ecosystems & Enwonment Farming Systems Dynamics: Impact of Increasing Population Density and the Availability of Land Resources on Changes in Agricultural Systems. The Case of Sukumaland, Tanzania. *Ecosyst. Environ.* **1996**, *56*, 203–215. [CrossRef]
45. Boserup, E. The Impact of Population Growth on Agricultural Output. *Source Q. J. Econ.* **1975**, *89*, 257–270. [CrossRef]
46. Jayne, T.S.; Muyanga, M. Land Constraints in Kenya's Densely Populated Rural Areas: Implications for Food Policy and Institutional Reform. *Food Secur.* **2012**, *4*, 399–421. [CrossRef]
47. Stephens, E.; Jones, A.; Parsons, D. Agricultural Systems Research and Global Food Security in the 21st Century: An Overview and Roadmap for Future Opportunities. *Agric. Syst.* **2018**, *163*, 1–6. [CrossRef]
48. Mango, N.; Makate, C.; Mapemba, L.; Sopo, M. The Role of Crop Diversification in Improving Household Food Security in Central Malawi. *Agric. Food Secur.* **2018**, *7*, 7. [CrossRef]
49. Campi, M.; Dueñas, M.; Fagiolo, G. Specialization in Food Production Affects Global Food Security and Food Systems Sustainability. *World Dev.* **2021**, *141*, 105411. [CrossRef]
50. Makate, C.; Wang, R.; Makate, M.; Mango, N. Crop Diversification and Livelihoods of Smallholder Farmers in Zimbabwe: Adaptive Management for Environmental Change. *SpringerPlus* **2016**, *5*, 1135. [CrossRef]
51. Maggio, G.; Sitko, N.J.; Ignaciuk, A. *Cropping System Diversification in Eastern and Southern Africa: Identifying Policy Options to Enhance Productivity and Build Resilience*; FAO: Rome, Italy, 2018.
52. Lukanu, G.; Green, M.; Greenfield, P.; Worth, S. Farmers' Cash Crop Cultivation Decisions in Southern Niassa Province, Mozambique. *Dev. South Afr.* **2004**, *21*, 531–554. [CrossRef]
53. Bruna, N. *Competitividade Do Algodão Em Moçambique*; Observador Rural; Observatório do Meio Rural: Maputo, Mozambique, 2014.
54. Mosca, J. Sector Familiar da Agricultura (3.9 Milhóes de Famílias): Cada Vez Mais Pobres e Marginalizados. In *Razões Económicas, Institucionais, Ideológicas e Políticas e Interesses Externos*; Destaque Rural; Observatório do Meio Rural: Maputo, Mozambique, 2019.
55. FEWSNET; SETSAN. *Moçambique—Descrição Das Zonas de Formas de Vida*; FEWSNET: Washington, DC, USA; SETSAN: Maputo, Mozambique, 2014.
56. Paganini, N.; da Ouana, R.F. *Mercados Locais Na Cidade e Província de Maputo: Relatório de Pesquisa Qualitativa*; Observatório do Meio Rural: Maputo, Mozambique, 2019.
57. Brito, R.; Holman, E. *Responding to Climate Change in Mozambique: Theme 6—Agriculture*; Observatório do Meio Rural: Maputo, Mozambique, 2012.

58. Marques, M.; Mafalacusser, J.; Brito, R.; Metzger, M.; Tadross, M. Assessing Future Impacts of Climate Change on Land Use and Land Cover: Actual and Potential Agricultural Land Use. In *INGC Climate Change Report: Study on the Impact of Climate Change on Disaster Risk in Mozambique*; Asante, K., Brundrit, G., Epstein, P., Fernandes, A., Marques, M.R., Mavume, A., Metzger, M., Patt, A., Queface, A., Sanchez del Valle, R., et al., Eds.; INGC: Maputo, Mozambique, 2009; pp. 89–117.
59. INE. *Estatísticas e Indicadores Sociais, 2013–2014*; Instituto Nacional de Estatistica: Maputo, Mozambique, 2015.
60. Béringuier, M. *Diagnosis of Agrarian Dynamics on the Eastern Slope of Mount Namuli & Analysis of Agricultural Practices into Deforestation Dynamics and Definition of an Agricultural Accompaniment*; Nitidae: Maputo, Mozambique, 2019.
61. Abbas, M. (In)Segurança Alimentar e Território Em Moçambique: Discursos Políticos e Práticas. *Rev. NERA* **2017**, *20*, 106–131. [CrossRef]
62. Yohannes, G.; Wolka, E.; Bati, T.; Yohannes, T. Household Food Insecurity and Coping Strategies among Rural Households in Kedida Gamela District, Kembata Tembaro Zone, Southern Ethiopia: Mixed methods Concurrent Triangulation Design. *BMC Nutr.* **2023**, *9*, 4. [CrossRef]
63. Tsegaye, A.T.; Tariku, A.; Worku, A.G.; Abebe, S.M.; Yitayal, M.; Awoke, T.; Alemu, K.; Biks, G.A. Reducing Amount and Frequency of Meal as a Major Coping Strategy for Food Insecurity. *Arch. Public Health* **2018**, *76*, 56. [CrossRef]
64. Farzana, F.D.; Rahman, A.S.; Sultana, S.; Raihan, M.J.; Haque, M.A.; Waid, J.L.; Choudhury, N.; Ahmed, T. Coping Strategies Related to Food Insecurity at the Household Level in Bangladesh. *PLoS ONE* **2017**, *12*, e0171411. [CrossRef] [PubMed]
65. Lasse, N.; Abbas, M. *Determinantes Da Escassez de Alimentos e Estratégias de Sobrevivência No Sector Familiar Nos Distritos de Nicoadala, Morrumbala e Gurué*; Destaque Rural Nº 258; Observatório do Meio Rural: Maputo, Mozambique, 2023.
66. Moore, N.; Alagarswamy, G.; Pijanowski, B.; Thornton, P.; Lofgren, B.; Olson, J.; Andresen, J.; Yanda, P.; Qi, J. East African Food Security as Influenced by Future Climate Change and Land Use Change at Local to Regional Scales. *Clim. Chang.* **2012**, *110*, 823–844. [CrossRef]
67. Ume, C. The Role of Improved Market Access for Small-Scale Organic Farming Transition: Implications for Food Security. *J. Clean. Prod.* **2023**, *387*, 135889. [CrossRef]
68. Bahta, Y.T.; Musara, J.P. Diversity of Food Insecurity Coping Strategies among Livestock Farmers in Northern Cape Province of South Africa. *Climate* **2023**, *11*, 82. [CrossRef]
69. Ouédraogo, M.; Zougmoré, R.; Moussa, A.S.; Partey, S.T.; Thornton, P.K.; Kristjanson, P.; Ndour, N.Y.B.; Somé, L.; Naab, J.; Boureima, M.; et al. Markets and Climate Are Driving Rapid Change in Farming Practices in Savannah West Africa. *Reg. Environ. Chang.* **2017**, *17*, 437–449. [CrossRef]
70. Otekunrin, O.A.; Otekunrin, O.A.; Sawicka, B.; Pszczółkowski, P. Assessing Food Insecurity and Its Drivers among Smallholder Farming Households in Rural Oyo State, Nigeria: The HFIAS Approach. *Agriculture* **2021**, *11*, 1189. [CrossRef]