FOCUS Vietnam

Farmer Options for Crops Under Saline conditions

Adapting to salinity in the Vietnamese Mekong Delta: impacts, crop diversification options and market engagement

Socio-economic theme final report

Paul Kristiansen and Michael Coleman (Editors)

University of New England

September, 2025

Contents

Acknowledgements

We acknowledge financial support for this research from the ACIAR-funded project 'SLAM/2018/144 - Farmer Options for Crops Under Saline conditions (FOCUS) in the Mekong River Delta, Vietnam. We greatly appreciate the contribution of all participants in the surveys, key informant interviews and focus group discussions that contributed data to this report.

From Soc Trang Departments of Agriculture & Rural Development (DARD), the following staff provided assistance in linking with survey respondents: Mr Tran Vinh Nghi, Mr Vuong Anh Tuan, Mr Huynh Duc Thang; while the following Hau Giang DARD staff provided this support: Dr Le Hong Viet, Mr Tran Van Vu. We also thank the private sector actors who participated directly and who helped us to connect with farmers and other value chain participants.

We are grateful to the enumerators for the efforts during household survey data collection: Vo Thi Ngoc Trinh, Le Thi Thuy Duong, Quach Tran Ngoc Tho, Chau Xuan Mai, Tran Quoc Ty, Nguyen Xuan Yen, Chau Thi Phuong Chuc, Dang Thi Thanh Ngan, Nguyen Thi Nhu Ngoc.

Executive Summary

Background

The Vietnamese Mekong Delta (VMD) is home to more than 20 million people. Agricultural production accounts for about 40% of regional GDP and provides a livelihood for over 75% of the population. Historically, year-round production of rice has been the dominant form of production in the VMD, however its sustainability is under threat due to the negative environmental impacts of high levels of input use, water scarcity (especially in the dry season and in drought years), and the increasing cost of inputs.

In response, the Government of Vietnam is advocating more widespread adoption of sustainable and climate resilient farm management practices, including production of vegetable and other crops, either in place of triple-rice or as a dry season rotation.

This report addresses several objectives of the FOCUS project via the following activities:

- Activity 1.2, collect information on the impact of saline intrusion in the VMD;
- Activity 3.1, identification of successful market and governance components of crop-based industries;
- Activity 3.2, an economic analysis of upland (dry season) crop options in the VMD;
- Activity 3.3, analysis of adoption constraints for diversification; and
- Activity 4.4, exploration of value chain development for novel crops in the VMD.

The data presented in this report was collected as part of a series of household surveys (HHS), key informant interviews (KII) and focus group discussions (FGD), as well as from FOCUS field trials. The HHS was conducted in three districts in Soc Trang and Hau Giang and covered topics across several socio-economic project objectives. The KIIs and FGDs were carried out in those three districts as well as at other locations across the VMD.

Salinity impacts and adaptation

Salinity has limited the productive capacity of considerable areas of land that have historically been dedicated to year-round production of rice in the VMD, and is expected to become more pronounced in the future. This is especially a problem in the dry season when saline intrusion is most significant.

As discussed in more detail in Chapter 2, we asked HHS respondents to consider the extent of salinity on their farm and in their district; the year it started becoming a noticeable issue; its severity at different times of year; the various impacts both on the farm and in the district; the on-farm and off-farm measures that may be implemented to adapt to salinity (including non-rice dry season crop production); areas in which further support was required to adapt to salinity; and the usefulness of currently available sources of information on adaptation.

This research suggested that salinity either was not considered to be a problem in Long My district, Hau Giang province, or that its impacts were not yet noticeable to farmer respondents at the time the HHS was carried out. Both surveyed districts in Soc Trang province, however, experienced noticeable levels of salinity, becoming a noticeable issue in Long Phu district before it became an issue in Tran De district.

Our findings confirmed earlier research that salinity is most severe in the VMD during the dry season, that is in the period from December to May. Many of the farmers we surveyed who considered themselves to be experiencing the impacts of salinity recognised three notable impacts on their farm and in their district: reduced crop yield; loss of farm income; and the need to work the land more intensively to maintain its level of productivity.

In saline-impacted areas such as Long Phu and Tran De districts, we might therefore expect that farmers were more likely to adapt to salinity by employing on-farm measures such as changing the crops they produce during the dry season to more saline-tolerant types. Nonetheless, relatively few farmers surveyed noted changes in the dry season crops they had grown. This may indicate that agricultural transformation in the VMD, in response to salinity, is still in its early stages.

We asked farmers to consider a range of on-farm and off-farm adaptations to salinity. On average, the respondents rated as the most important adaptations increasing the amount of time they worked off-farm, and starting a new business. Both constitute income diversification measures without changing farm practices. When considered alongside the importance given to dry season fallowing and producing less on the farm, a potential shift away from farming to other means of income generation is implied. Such a shift may pose future concerns in the VMD including labour shortages for remaining farm operators and reduced food security for the region and Vietnam as a whole, given the country’s reliance on the VMD as its most important food bowl.

Some adaptation measures that were considered less effective included constructing new drainage infrastructure, transitioning to non-crop farm production, improving the efficiency of growing existing crops, growing different crops in the dry season, and cultivating different varieties of the same crop in the dry season. However, these measures require a certain amount of up-front and/or ongoing investment, and this option is not likely to be available for many smallholder farmers due to their limited capital resources or access to credit.

Growing different crops in the dry season and growing different varieties of the same crop in the dry season, were perceived as the least effective adaptation measures. Although these adaptation measures were encouraged by the government and experts, they do present farmers with challenges including availability of relevant knowledge and skills to grow alternative crops. This implies that further support is needed to maximise successful adoption of non-rice dry season cropping by farmers.

Amongst our respondents experiencing salinity, there appeared to be a considerable need for information and support on adaptation across all technical, agronomic, marketing and infrastructure areas. This is likely to be related to their historic familiarity with rice production, and the relative newness of wider-scale adaptation in the form of growing alternative crops. Of the sources of information that farmers might rely on to adapt to salinity, Departments of Agriculture & Rural Development (DARD) and family/social networks were the most highly rated. Information provision on salinity adaptation may continue to be provided through a variety of means to ensure maximum reach of the target audience.

Determinants of adaptation strategies in response to salinity

In the study detailed in Chapter 3, 203 farmers in Soc Trang province were surveyed regarding factors affecting farmer choice of adaptation strategies to the situation of salinity intrusion in farming. Multivariate probit models were used to analyse the data and suggestions are offered to local authorities and farmers to improve adaptation to this issue.

About 38% were aware that their fields were affected by saline intrusion. Respondents considered that salinity levels were at their highest from February to April, reducing crop productivity and ultimately farmer income during this time of year on impacted farms.

Faced with these negative impacts of salinity, farmers implement some strategies to minimise losses. Three such strategies were explored in this research: conducting business operations to diversify household income sources; increasing the amount of time worked off-farm; and changing crop types/crop varieties. The multivariate probit model indicated that each strategy was either positively or negatively influenced in different ways by a range of socio-demographic, economic and farm business, and environmental and agronomic factors. Among the adaptation strategies, changing crop varieties has not been as effective for farmers as the other approaches. The lower efficiency level may be attributed to the limited availability of crop varieties with significantly enhanced salt tolerance.

Recommendations arising from the research for local authorities include: improve salinity forecasting capacity and provide information to farmers in a timely manner; work with researchers to adjust crop production schedules in response to saline intrusion; improve delivery of high quality and where possible, more drought and saline tolerant crop seedlings to farmers; foster off-farm business development in the province to provide diverse non-agricultural employment opportunities; provide vocational training to farmers; and consider loan provision to farmers to allow them to implement on-farm adaptation measures.

Recommendations for farmers include: seek up to date information from all relevant sources on saline intrusion in the district to allow timely adaptation to changing conditions; follow instructions regarding 'saline-adaptive' crop production schedules provided by government/researchers; actively implement adaptation measures on-farm (e.g. growing different dry season crops; improving water storage); improve skills in on-farm adaptation measures via training opportunities; consider implementing off-farm adaptations to ensure ongoing family financial security (e.g. business development, crafts, off-farm employment) and seek skills improvement opportunities to make these adaptations more feasible.

Farming household socio-economic characteristics

Chapter 4 summarises socio-economic and demographic information about HHS participants, including: the location of the participants; participant and household age, gender and household role profiles; ethnicity; educational attainment; farm experience and succession planning; household expenditure and off-farm income sources. Previous research indicates that a range of demographic, farm production system and household economic factors can influence smallholder willingness and capacity to adapt to climate change impacts such as salinity.

Farming household typologies

Chapter 5 presents a typology of farmers to identify the potential implications of different farmer types for adaptation and intervention design.

The VMD is critical for local incomes, national food security and agricultural exports. However, agricultural production faces serious bio-physical threats including climate change, saline intrusion and freshwater scarcity. An option for smallholder farming households is to switch from rice to alternative crops, especially during the vulnerable dry season. Farmers are heterogenous and may respond differently to drivers of change, therefore, farmer typologies can help identify shared attributes and allow for targeted policies and support for adaptation. Our objective was to illustrate how farmer heterogeneity and associated economic performance, together, can identify patterns in smallholder experience of this form of adaptation in the VMD. Such patterns may be useful in informing design and implementation of tailored interventions to support farm systems transformation, in the VMD and elsewhere.

A household survey was conducted in 2021-2022 in Hau Giang and Soc Trang provinces in the VMD to collect data about climate change impacts, adaption, capacity and needs. Data were analysed using factor analysis with quantitative and qualitative variables followed by hierarchical clustering to obtain farmer typologies. Household adaptive capacity and agricultural production performance were then compared among the typologies. Twenty variables were categorised into four groups based on literature and local consultation: demographic characteristics, economic resources, farming systems and production challenges.

The factor analysis and clustering identified three farmer typologies: Cluster 1 (Most resilient farmers), Cluster 2 (Moderately resilient farmers) and Cluster 3 (Least resilient farmers). Cluster 1 had greater adaptive capacity, operated at a larger scale and incurred lower costs. Cluster 3 had low adaptive capacity and faced the most severe production challenges, particularly salinity.

These findings have implications for how different categories of farmers adopt and maintain new forms of production, confirming the need for policy design and implementation that accounts for farmer heterogeneity in the two provinces and beyond. Less resilient farmers in particular are likely to benefit most from many forms of external top-down assistance, with a particular focus on ethnic minorities and women farmers. Support for more profitable and experienced farmers can be focused on labour shortages and facilitating larger-scale production.

Householder decision-making for dry season crop production

Chapter 6 presents information regarding the reasons for growing the most common non-rice dry season crops either in the field or on the embankment; sources of information used to grow these non-rice crops; sales/marketing pathways for dry season crops; and the advantages and disadvantages of selecting the dry season crop options (field and embankment) grown by the HHS respondents.

The reasons for crop selection were, in general, grouped according to economic, agronomic and farm system management factors:

- Economic: high and/or relatively stable price and acceptable to high profitability; relatively easy access to a stable market for the crop; high yield; improve overall household income.
- Agronomic: drought/dry season tolerant (low water requirements); relatively disease/pest tolerant; growing quickly; adapted to the soils prevalent in the region; useful for soil conditioning/improvement.
- Management: prior household experience in growing the crop; access to support from neighbours; easy to grow and harvest; relatively low input requirements (labour, fertiliser, pesticide, capital); make full use of the land (e.g. rather than a dry season fallow).

HHS interviewees were also asked to describe who purchased their crop's produce and what proportion was purchased by different entities, who decided on the price received, and to rate their satisfaction with the price received. Local wholesalers were the most significant avenue of crop sales amongst the farming households in this study, followed by middlemen and local wet market retailers. Decisions regarding price received was most commonly the result of negotiation between buyer and seller, however for many of the farmers surveyed buyers set the price they were willing to pay. The interviewees were, overall, relatively ambivalent regarding their satisfaction about the price received. Interviewees were most likely to seek alternative buyers if they wished to improve the price received for their crop.

Interviewees were asked to list the production advantages and disadvantages of the dry season crops grown. No clear pattern was evident in relation to particular crops, however in general terms the advantages of dry season crops included being considered easy to grow and manage, to grow quickly, and to be relatively efficient in their use of labour, water, fertiliser and pesticide, and to be prone to relatively less incidence of pest and disease. Drought and/or salinity tolerance was rarely mentioned. Potential disadvantages included intolerance of wet conditions and waterlogging, proneness to certain pests and diseases, and high input prices. Taking these advantages and disadvantages into account, over 90% of the interviewees indicated that they would be prepared to grow the same dry season crops again.

Farmer perspectives of alternative crop profitability

Chapter 7**Error! Reference source not found.** presents a quantitative analysis of the relative profitability of the various dry season rice-alternative crops covered by the HHS, as well as the factors impacting their profitability.

In response to climate-change associated declines in year-round rice production system yields, farmers in the VMD are increasingly shifting towards production of alternative annual vegetable crops, or diverse rice-annual crop systems including field cropping and/or the surrounding bunds (embankments). However, knowledge about the profitability of these alternative crops remains limited.

We investigated the relative profitability of alternative crops in two provinces of the VMD and factors influencing their profitability. The research was completed via a household survey, using descriptive analysis and multiple linear regression to estimate profitability models.

While alternative annual field crops appeared generally to be more profitable than rice, farmers with access to more experience, education, land area and labour resources were likely to be more profitable. In contrast, increased seed, fertiliser use, and longer growth duration was associated with reduced profitability of field crops. Bund crop production was negatively associated with larger land area. Use of different information sources had mixed relationships with the profitability of crops in both field and bund systems.

The research indicates that alternative crops are generally profitable for former rice farmers and provide a sustainable option to adapt to climate change impacts. The research also offers insights for policymakers and extension practitioners to better support transitioning farmers to maximise their profitability and enhancing their resilience, by identifying which crop options may be more profitable in field or bund contexts, and which characteristics farmers may develop within their business to further enhance their profitability.

Field assessment of alternative crop profitability

Chapter 8 provides some economic analysis of the production from field trials. More detailed economic analysis of farmer perceptions of alternative crops grown in the lower MRD has been provided in Chapter 7. The economic analyses of field trials show promising financial benefit to farmers growing upland crops. It is noted that in some cases, higher prices may have been taken due to novelty of the crops produced and that it farmers adopted these crops more broadly, supply may decrease price obtained. Alternatively, if secure supply chains could be created, prices may remain high even with greater supply owing to more demand from a secure market.

Value chain development for new crops

Chapter 9 presents results from the FOCUS household survey on how farmers in the VMD engage with buyers for their crops in the market, as well as a review of literature that focuses on the development of value chains for new crops in the VMD in response to challenges posed by climate change.

Membership of a farmer collective was the most common source of support and method by which farmers surveyed marketed their crops. None of the farmers surveyed had signed a contract with a buyer. Where respondent farmers did have support of an external organisation (such as a collective) to market their crops, they indicated on average relatively high levels of cost effectiveness and satisfaction with these arrangements. However, over half of all farmers had no marketing arrangements in place, indicating an opportunity to link more farmers with external marketing support.

While none of the farmers surveyed participated in contract farming, respondents did provide their thoughts on the advantages and disadvantages of contract farming. Price stability and access to additional resources such as farm inputs and training counted amongst the advantages; while strict quality guidelines, slow payment procedures and being "locked in" to an arrangement were noted amongst the disadvantages.

None of the farmers surveyed indicated that they had received training or advice in the area of marketing, but some did note that they would appreciate training in sales pathways, including online marketing, and that this would be welcome if provided by DARD, other extension providers, and other members of farmer collectives or co-operatives.

The FOCUS project aims to promote the production of alternative crops to enhance farmer resilience to salinity impacts. However, markets for these new crops are currently undeveloped, presenting challenges for farmers seeking economically viable alternatives. The review sections of this chapter explored the impact of increasing production scale on prices, the influence of market signals on price changes, and the effects of processing on agricultural product prices. It emphasised the importance of market development, improving value chains, and ensuring access to stable markets to support the successful introduction of new crops in the VMD. There is a need to enhance market access, processing capacity, and value chain integration to improve income stability and promote the adoption of new crops by smallholder farmers in the VMD.

Case studies of successful crop-based business operations in the VMD

This research (Chapter 10) sought to identify and analyse market and governance components of successful crop-based industries in the VMD. It is an initial assessment to identify relevant institutions in the wider agricultural industry, and social factors and institutions that enhance or stifle the adoption process. The research team worked with government and business to select participants for a series of HHS, KIIs and FGDs with value chain stakeholders from farmers to retailers as well as supporting stakeholders in government and NGO sectors. Focusing on six successful case studies of crop-based industry, the HHS, KIIs and FGDs acquired data about drivers and barriers in production, marketing, organisational structures and policies. "Successful cases" were identified by the authorities of Sub-DARD and experts. "Successful" was defined as collaboration or transaction between the cooperatives, producers and enterprises, as well as successful market consumption or sale to processing companies having been in operation for some years.

From the six case studies, three groups of business models were identified:

- Gathering of small groups of farmers into *co-operatives*, representing farmers in matters of obtaining inputs and making sale to improve efficiency and provide a collective voice.
- A *corporate-led community-based approach* linking production with consumption, with a corporation fostering organic practices, inclusion of indigenous farming knowledge and creating other opportunities for on-farm income generation.
- *Corporate investment in crop research and marketing activities* to disseminate or upscale production of novel crops.

These are three business model that FOCUS can choose to upscale the crops that may be introduced at the end of the project. All three of them have both advantages and constraints at present and in the future.

Preliminary findings from the six cases indicate that the scale of business remains relatively small and therefore weak in aspects of their operation. These upland cases are quite unique given that market engagement and collaboration for upland crops has been less popular in comparison to rice cases. However, the three business models provide good examples of the types of business model that the FOCUS project or other research may consider in disseminating new crops or technologies to the farming sector, or in terms of market engagement.

The factors that lead to successful market engagement included effective leadership of the heads of cooperatives or enterprises. This was one of the most important factors that maintains market-oriented production in all six cases. Sufficient product demand was a core factor leading to sustainable linkages between output enterprises and cooperatives, or enterprises and groups of farmers. Support from the government to promote cooperative development, start up and innovation may provide further opportunities for these cases.

Several constraints in the development of the private and market engagement were also identified. These included low market demand, the small scale of both businesses and farming practices, and possible restrictions on the possibilities of upscaling these three business models. Other factors include details in contracting schemes, and fear of loss. Further analysis will go deeper into each of the six cases, to understand the relationship among stakeholders leading to the success or constraint in their business.

Chapter 1. Introduction

Paul Kristiansen and Michael Coleman

1.1 Background

The Vietnamese Mekong Delta (VMD) is home to more than 20 million people. Agricultural production accounts for about 40% of regional GDP and provides a livelihood for over 75% of the population (Mackay & Russell 2011). The agri-food sector in Vietnam has changed significantly, particularly since the 1980s, in response to the *Doi Moi* programme of economic liberalisation, which focused in part on national self-sufficiency objectives as well as improved productivity and intensification in the agricultural sector (Mackay & Russell 2011, World Bank 2016b). In the VMD, intensification in the form of year-round rice production (three crops annually, or 'triple-rice') was made possible by development of interconnected water storage infrastructure and networks of protective dikes. This underpinned significant growth in the agricultural productivity of the region (World Bank 2016a, Nguyen et al. 2020a).

However, intensive year-round rice production depends on large and increasing quantities of farm inputs (e.g. fertiliser, water) to maintain desirable yield levels. These practices may not be sustainable in the longer-term due to the negative environmental impacts of high levels of input use, water scarcity (especially in the dry season and in drought years), and the increasing cost of inputs as a proportion of crop sale price (World Bank 2016b). Climate change is also reducing the productivity of considerable areas of land that has been dedicated to year-round rice production in the VMD, and this is expected to become a more significant problem in future (Jiang et al. 2019, Kaveney et al. 2023).

In response to anticipated difficulties in maintaining intensive triple-rice production, the Government of Vietnam is advocating more widespread adoption of sustainable and climate resilient farm management practices (Government of Viet Nam 2021) including production of vegetable and other crops, either in place of triple-rice or as a dry season rotation (Fedele et al. 2019, MARD 2023).

1.2 Purpose and objectives

This report addresses several objectives of the ACIAR-funded FOCUS project (SLAM/2018/144):

- Objective 1.2, collect information on the impact of saline intrusion in the VMD;
- Objective 3.1, identification of successful market and governance components of crop-based industries;
- Objective 3.2, an economic analysis of upland (dry season) crop options in the VMD;
- Objective 3.3, analysis of adoption constraints for diversification; and
- Objective 4.4, exploration of value chain development for novel crops in the VMD.

These objectives were addressed via a range of public consultation, fieldwork and desktop review activities. The methodology, results and significance of these activities are outlined in the chapters provided below. Each chapter has been written as a standalone report to facilitate further reading on specific topics.

Chapter 2 presents information arising from the survey regarding the various socio-economic impacts of salinity in the VMD, and is relevant to FOCUS Objectives 1.2 and 3.3

Chapter 3 discusses the determinants of adaptation strategies to saline intrusion among upland-crop farmers in a coastal province in Vietnam. The results are relevant to FOCUS Objectives 1.2 and 3.3.

Chapter 4 presents summary demographic and economic information for the HHS respondents, including: the location of the respondents; respondent and household age, gender and household role profiles; ethnicity; educational attainment; farm experience and succession planning; household expenditure and off-farm income sources. This information is relevant to all five FOCUS Objectives addressed by this report.

Chapter 5 presents a typology of farmers to identify potential implications of different farmer types for adaptation and intervention design. The findings relate to FOCUS Objectives 3.1, 3.2 and 3.3.

In Chapter 6, we present information on decision-making in terms of selecting from amongst the dry season crop options, pathways of sale, and the various advantages and disadvantages of producing different crops. The results are relevant to FOCUS Objectives 3.1 and 3.3.

Chapter 7 contains a quantitative analysis of the relative profitability of the various dry season rice-alternative crops covered by the HHS, as well as the factors impacting their profitability. The results are relevant to FOCUS Objectives 3.2 and 3.3.

Chapter 8 field assessment of novel dry season crops, addressing FOCUS Objectives 3.2 and 4.4.

Chapter 9 includes results from the HHS on how farmers in the VMD engage with buyers for their crops in the market, and presents a review of the literature on development of value chains for new crops in the VMD in response to challenges posed by climate change. The information is of relevance to FOCUS Objective 4.4.

Chapter 10 summarises the activity to identify and analyse market and governance components of successful crop-based industries in the Mekong Delta. It is an initial assessment to identify relevant institutions in the wider agricultural industry, and social factors and institutions that enhance or stifle the adoption process. This research is of relevance to FOCUS Objectives 3.1 and 3.3.

Chapter 2. Salinity impacts and adaptation measures

Paul Kristiansen, Michael Coleman, Le Thanh Sang and Mao Huynh Nhu

2.1 Introduction

The Vietnamese Mekong Delta (VMD) faces significant impacts from climate change, particularly involving increased frequency and severity of salinity (CCAFS-SEA 2016, Le et al. 2024a). The coastal provinces of the VMD have been especially affected (Hoan et al. 2019, Loc et al. 2021b, Tran et al. 2024a), leading to significant reductions in rice yields during the dry season, greater unpredictability in agricultural production, and negative impacts on the livelihoods of many farmers in the region (Tran et al. 2022a, Mills et al. 2023, Tran et al. 2023). The vulnerability of the coastal provinces of the VMD is further exacerbated by their dense population and significant dependence on agriculture for farming livelihoods, compelling many smallholder farmers to seek alternative sources of income (Betcherman et al. 2021, Le & Vo 2021, Tran et al. 2021a, Tran et al. 2021b).

In response, the Government of Vietnam advocates climate change adaptation in the form of sustainable and climate resilient farm management practices, as illustrated in Resolution 120 and the Agricultural Restructuring Plan (Government of Viet Nam 2021). This approach includes changing from year-round rice production to production of other annual/seasonal crops such as vegetables, either in rotation with rice (which would still be produced outside the dry season) or as a year-round alternative to rice. Recently, the Ministry of Agriculture and Rural Development (MARD) suggested that more than 85,000 hectares of less productive rice farm area may be used instead to produce non-rice annual crops, perennial crops, or for integrated rice and aquaculture – for example, rice-shrimp systems (MARD 2023).

Farming production systems diversification in response to environmental stressors is common in major river plains and delta systems globally, for example in the Ganges-Brahmaputra-Megna (Alam et al. 2017, Bernzen et al. 2023), the Nile (Ammar 2022), the Indus (Tuladhar et al. 2023), and the Red River Delta (Thanh et al. 2005), sharing many similar features with the VMD in terms of challenges and forms of adoption. Agricultural transformation by smallholder farmers around the world is f aced with several other issues besides salinity. These other issues include

- Other bio-physical impacts such as climate change impacts, e.g. increased pest and disease infestation
- Demographic changes, e.g. migration, aging farmer populations
- Agribusiness restructuring, e.g. increased focus on cash crops and export markets, reduced role of traditional markets, increased compliance and certification requirements
- Transborder resource conflict and geo-political relationships

These factors may further constrain adaptive capacity and need to be considered when planning and implementing rural development interventions to address the impacts of saline intrusion on cropping systems.

In this chapter, we present information on the impacts of salinity on smallholder farming households in the study area, including information on the extent of salinity; the year it started becoming a noticeable issue to those respondents who experienced the problem; its severity at different times of year; and the various impacts both on the farm and in the district. The chapter also includes an assessment of measures that respondent households may have taken up to adapt to salinity on their farm. These include various on-farm as well as off-farm adaptations. Respondents were also asked to: identify areas in which they required further support to adapt to salinity; to rate the usefulness of currently available sources of information on adaptation; and to assess non-rice dry season crops as a potential adaptation measure.

2.2 Methodology

The methodology described below applies to Chapters 2, 4 and 6, all of which draw their findings from the same HHS.

2.2.1 Survey development

The HHS instrument was developed in the period October 2021 to February 2022. Topics and questions were based on the broad research questions relevant to the FOCUS project's socio-economic and market chain objectives (see 'Introduction') and refined by members of the FOCUS socio-economics team as well as other key personnel involved in the FOCUS project.

The household survey was completed using the KoboToolbox data collection suite, chosen because of its cost-effectiveness, team familiarity with this system compared to other similar tools, and proven reliability when used in the field by team members for previous research. Data were collected by enumerators using tablet devices, and completed surveys were uploaded automatically to the KoboToolbox server to eliminate the need for data entry.

To facilitate involvement in the survey instrument design by Australian team members, and in support of human research ethics approval, the instrument was initially designed in the English language. Once finalised, it was translated into Vietnamese for implementation in the field.

Human research ethics approval was obtained from the University of New England for the research (HE22-004) in February, 2022.

The KoboToolbox survey form was piloted in May and June 2022 to identify any remaining issues, first using a draft paper version of the form and secondly using the KoboToolbox form. Piloting involved several farmers, government officials and project research colleagues. Feedback from the piloting was used to carry out minor refinements to the final KoboToolbox survey instrument.

Once the HHS form had been designed in KoboToolbox and piloted, five enumerators were employed by the project team, all of whom were 2nd and 3rd year students at Can Tho University. The enumerators were provided training in June, 2022, both in the survey objectives and purpose of the questions, and in using KoboToolbox (Figure 1).

Figure 1. Enumerator training in Kobo online data collection platform, June 2022

2.2.2 Conducting the survey

Data collection commenced on 12 July, 2022 in Long Phu district, Soc Trang province; on 22 July in Tran De district, Soc Trang province; and on 27 August in Long My district, Hau Giang province. Data collection was completed on 30 August (Figure 2 and Figure 3). Each survey required approximately 45-50 minutes to complete and involved enumerators visiting farmers either at their household or in their fields. GPS coordinates were used to note farm locations. Government COVID-19 safety protocols at the time the survey was carried out were complied with to minimise the risk of COVID-19 transmission, and included mask wearing, social distancing and use of hand sanitiser.

The research team adjusted to some problems that became evident during the field work:

- In the research area, a relatively small proportion of farming households were found to rotate rice with other crops (the focus of the HHS). Farmers were generally found to leave their ground to fallow during the dry season rather than take an opportunity to grow other crops, and during this time to take other forms of employment. As a result, the research team needed to use a non-probability sampling technique (Galloway 2005) that involved identifying and then surveying those farming households growing non-rice dry season crops.
- Women in the study districts were somewhat reluctant to participate in face to face interviews given that they often considered themselves not directly involved in farm production for their household, and therefore unable to answer more specific questions about cropping and their farm system. Previous cases of fraudulent behaviour by those purporting to carry out surveys also made women reluctant to place themselves in a position of being ‘tricked’ by the enumerators. The research team found that the best approach was again a non-probability sampling method in which women who noted that they were actively involved in their household’s farm business were targeted for the survey. Once the enumerators explained that they were university students and outlined the purpose of the research, women farmers were found to be more willing to participate.
- Survey completion in Long My district, Hau Giang province was relatively more challenging due to the difficulty in navigating from one farm to the next. The research team was required to travel by boat or ferry, or in some cases on excessively wet/muddy roads.
- In each study area, the research team was supported by local authorities to find farmers for interviews, which was of great benefit particularly in more remote areas.

Figure 2. Household survey data collection, Soc Trang province, July 2022

Figure 3. Household survey data collection, Hau Giang province, August 2022

2.2.3 Data cleaning

Data were checked visually by sorting columns to identify outliers in terms of potential outliers, obviously incorrect data, and impractically high or low levels of crop revenue, costs and profitability for the land area planted. Where needed, figures were corrected, for example where it was apparent that an extra 'zero' had been included by the enumerator.

2.2.4 Data analysis

Analysis of the data was carried out using SPSS (IBM Corp 2023) and R (R Core Team 2022b). Qualitative responses were coded using Microsoft Excel using thematic analysis of the text responses (Kiger & Varpio 2020), and coded data analysed using Microsoft Excel and SPSS (Microsoft 2019, IBM Corp 2023). Maps were produced using ArcGIS Pro (Esri 2022).

The analysis included descriptive statistics (means, frequencies, cross-tabulation, pivot tables). Cross-tabulation of selected variables sought identify any potentially significant relationships between variables and were utilised in the report where the Chi-square test identified a statistically significant relationship ($p \leq 0.05$). Chi-square test results are reported below cross-tabulation tables where these have been included in the results. R was used to produce a pivot table to summarise average cost, revenue and profit of dry season crops, and conditional formatting applied to help identify patterns in the resulting summary table.

2.3 Results

2.3.1 Impacts of salinity

Saltwater intrusion has become increasingly prevalent in recent years, occurring more frequently and with greater severity. Understanding the pattern of saltwater intrusion can empower individuals to adapt to these changes more effectively. Over 38% of survey respondent households reported experiencing saltwater intrusion in their fields. Figure 4 illustrates the distribution of water sources utilised by farmers for irrigation purposes. The results indicate that most farming households relied on water from canals, rivers, or irrigation canals, accounting for over 92% of respondent households. Rainwater was the next most common source, utilised by over 46% of respondent households. Pumping water from wells was also an option for over 15% of respondent households, while the least common method was storing water in fields, employed by less than 7% of respondent households.

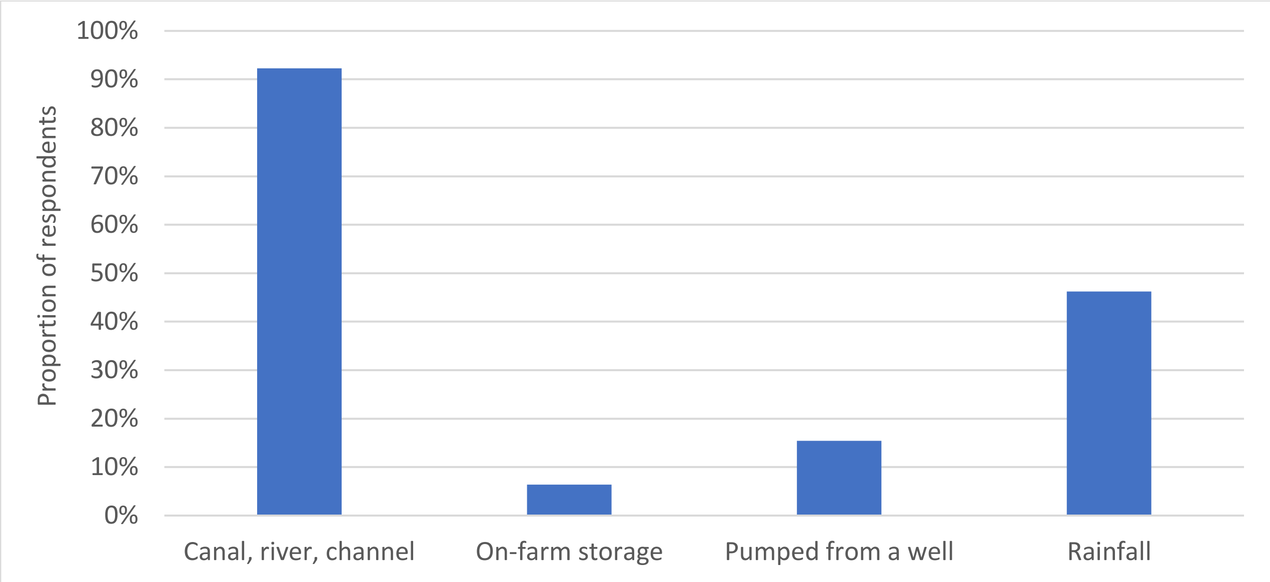

Figure 4. Sources of irrigation water (proportion of respondents).

Just over 26% of interviewees (78 of 299 total interviewees) indicated that salinity was a problem on their farm. Salinity was most likely to be a problem in the Long Phu district followed by the Tran De district, both in Soc Trang province. No instances of salinity were recorded amongst interviewee farms in Long My district, Hau Giang province (Table 1). Enumerators noted that in Hau Giang province, government establishment of localised embankment systems have largely protected farmers, although some mild salinity still occurs in this province each year. This means that it is not believed to affect farming fields and crop production, or that the salinity is only thought to be found outside farm fields, which are considered to be protected by embankments. Likewise, embankment systems are considered to have reduced the severity of the salinity problem in Soc Trang province to some extent.

Table 1. Whether salinity is a problem on the farm, by district

District	n	Whether salinity is a problem on the farm (%)	
		Problem with salinity	No problem with salinity
Long My, Hau Giang	95	0.0	100
Long Phu, Soc Trang	100	39.0	61.0
Tran De, Soc Trang	104	37.5	62.5

Pearson Chi-Square = 49.203; p = <0.001

Those interviewees who indicated that salinity was a problem on their farm were asked to provide more details to outline the nature and extent of its impacts on their farm system, household and also in their district. The mean proportion of interviewees farms impacted by salinity (for those who had noted a salinity issue) was 56.5% (standard deviation 32.1%; minimum 2% and maximum 100%). For nearly 60% of these interviewees, at least 50% of their farm land was impacted by salinity. Nearly 25% of interviewees who had a salinity problem indicated that 100% of their farm land was impacted.

Those interviewees who had a salinity problem on their farm were asked to indicate which year this had started to become a problem (Table 2 and Figure 5). Amongst all interviewees, the years 2019, 2016 and 2020 were particularly notable as years when salinity had first become noticeable. When the response is broken down by region, a general pattern is evident whereby salinity appeared more likely to become a noticeable issue at an earlier point of time in the Long Phu district, and to be a more recent phenomenon in the Tran De district (particularly in 2019).

Table 2. The year salinity started becoming noticeable on the farm (count of responses by district)

Year salinity started becoming a noticeable problem	Long Phu district (no. respondents)	Tran De district (no. respondents)	All interviewees with a salinity problem (no. respondents)
2008	1	-	1
2010	2	-	2
2015	2	1	3
2016	12	3	15
2017	8	2	10
2018	2	6	8
2019	3	20	23
2020	6	7	13
2021	2	-	2
2022	1	-	1
Total	39	39	78

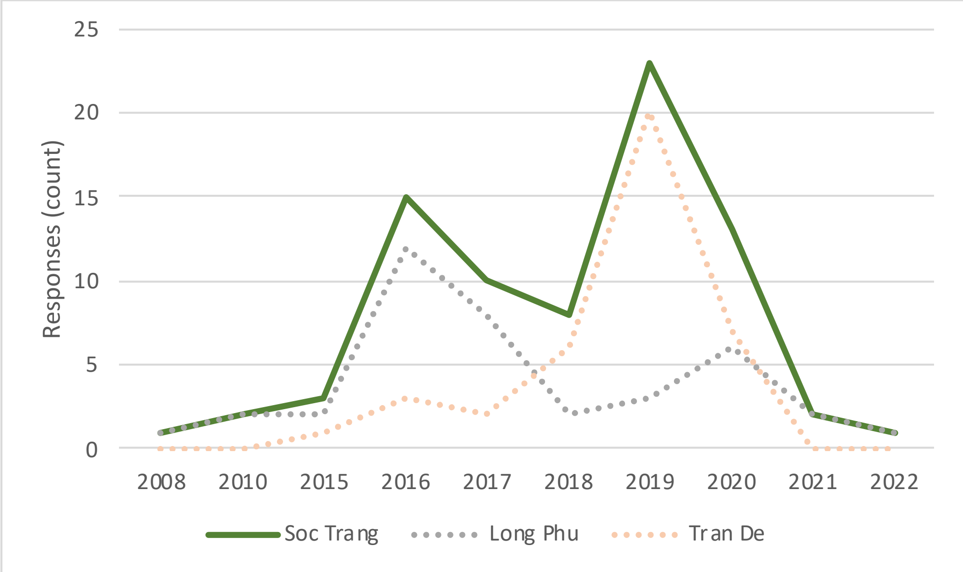

Figure 5. The year salinity started becoming noticeable on the farm (count of responses by district)

Salinity is likely to have a different extent of impact at different times of the year – most importantly as a result of rainfall and seasonality (i.e. wet and dry seasons). As a result, those interviewees who had a salinity issue on their farm were asked to rate the extent of the salinity problem on their farm for each month of the calendar year. A rating of "0" indicated no problem with salinity for the month in question, while a rating of "5" indicated the most severe salinity problem for the month in question.

The results in Table 3 and Figure 6 suggest that the problem of salinity is at its most severe amongst interviewees overall in the months of February to May, but particularly in the months of March and April where the mean rating score provided by interviewees was highest. Salinity appears to be a relatively less severe problem in the months of September to November. At the district level, for most months of the year (other than in April and May) interviewees in the Long Phu district considered salinity to have a higher severity rating than their counterparts in Tran De district (Table 3 and Figure 6). Potentially, this may be related to the longer-term overall presence of salinity in the Long Phu district (Table 2 and Figure 5).

Table 3. Mean scores for the severity of the salinity problem for each month of the calendar year, where "0" = no problem and "5" = the most severe problem

Month	Long Phu district (n = 38)	Tran De district (n = 39)	All interviewees with salinity problem (n = 77)	Standard deviation (n = 77)
January	2.13	1.59	1.86	1.24
February	2.92	2.31	2.61	1.78
March	3.82	3.64	3.73	1.54
April	3.24	3.85	3.55	1.42

May	2.13	2.26	2.19	1.42
June	1.47	1.44	1.45	0.84
July	1.32	1.21	1.26	0.50
August	1.39	1.26	1.32	0.52
September	1.37	1.18	1.27	0.48
October	1.32	1.15	1.23	0.48
November	1.29	1.21	1.25	0.54
December	1.66	1.46	1.56	1.05

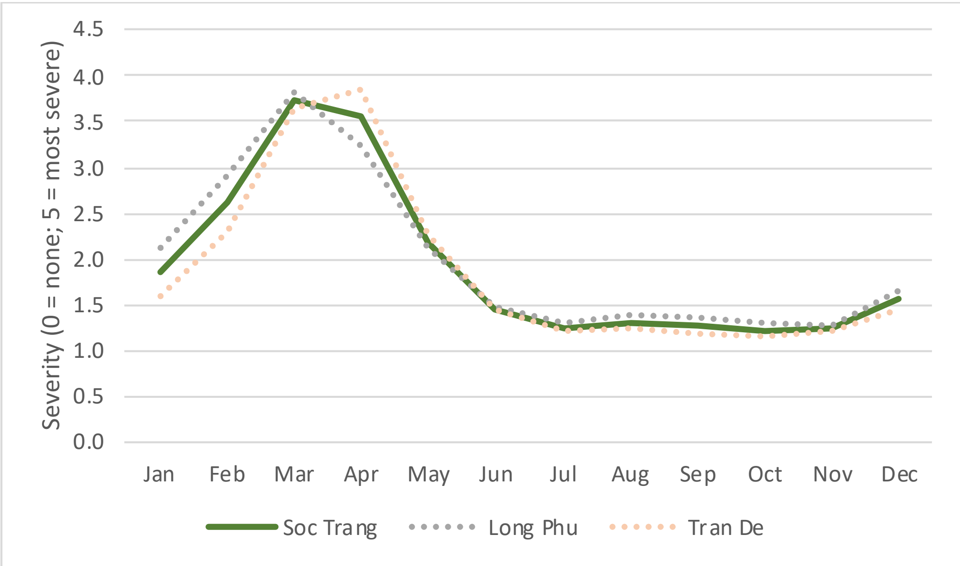

Figure 6. Mean scores for the severity of the salinity problem for each month of the calendar year, where "0" = no problem and "5" = the most severe problem

Salinity was most likely to have the impact on-farm (Table 4) and in the district (Table 5) in terms of decreasing the agricultural yield of the farm land, an issue noted by approximately 85% of interviewees. Two-thirds of interviewees considered that salinity resulted in loss of farm income on their own farm, and almost three-quarters noted this to be an impact at district level, while over half noted that more work was required on the farm to maintain its level of productivity in the face of salinity impacts. Relatively few considered that salinity had brought about a change in the dry season crops they grew, that there were fewer off-farm work opportunities, or that there was an impact in the distribution of activities between women and men in the household. Interviewees were asked to indicate if they had noted any other impacts of salinity at the farm or district level, but none were noted.

Table 4. Impacts of salinity on the farm

Salinity impacts on the farm	All interviewees with a salinity problem (%; n = 78)
Decreased agricultural yield	84.6
Loss of income	66.7

More work required to maintain productivity	56.4
Changes in dry season crops grown	6.4
Changes to distribution of work available for women versus men	5.1

Table 5. Impacts of salinity in the district

Salinity impacts in the district	All interviewees with a salinity problem (%; n = 78)
Decreased agricultural yield	87.2
Loss of income	74.4
More work required to maintain productivity	60.3
Fewer work opportunities off-farm	9.0
Changes in dry season crops grown	5.1

2.3.2 Adapting to salinity

Adaptation measures

Interviewees who had a salinity problem on their farm whether they had made a range of changes to adapt to salinity; and if so, how effective these changes had been in maintaining the productivity of their farm. Table 6 shows the most effective adaptations included focusing on non-farm income sources: spending more time working off-farm, often involving multiple members of the household; and starting a new business. On-farm adaptations that were rated relatively highly for their effectiveness included constructing new drainage infrastructure, avoiding growth of crops during the dry season, and changing to non-crop farm production (e.g. livestock). Growing different crops (e.g. vegetables) and growing different varieties of the same crop (e.g. more saline-tolerant rice varieties) received relatively low ratings. Fallowing fields during the dry season and constructing new drainage infrastructure featured as the most common on-farm adaptation measures.

Table 6. The effectiveness of changes made to adapt to salinity on the farm – number of responses and mean rating, where "1" = not effective at all and "7" = extremely effective.

Changes made to adapt to their salinity and their effectiveness	Mean rating	Std dev	n
Increase time spent working off-farm	6.0	1.3	16
Start a new business to diversity household income sources	5.9	0.8	20
Construct new drainage infrastructure	5.7	0.9	50
Do not grow crops during the dry season	5.6	1.7	65
Change to non-crop farm production	5.4	1.9	9
Produce less on the farm e.g. take saline-affected land out of production	5.0	1.5	29
Improve efficiency of growing existing crops	4.7	1.5	35
Grow different crops in the dry season	4.6	2.1	21
Grow different varieties of the same crop in the dry season	2.5	2.2	15

New crops as a potential adaptation measure

Perhaps surprisingly, only 8 interviewees out of the 78 that had noted a salinity problem on their farm (just over 10%) were considering growing any new crops in response to salinity. Enumerator discussion with research participants suggested that the relatively small number of farmers considering alternative crops stemmed from lack of concern about the potential impacts of salinity, as well as comfort and familiarity with their current rice-based production system. These interviewees were further asked which crops they were considering as an adaptation to salinity, and their reason for this choice. Given the small number of responses the information provided is quite limited, however reasons for selection of particular dry season crops included:

- Salt tolerance (corn)
- High price available for the crop type (spring onions)
- Availability of a range of varieties (crop not specified)
- Adaptability to weather (crop not specified)
- Ability to earn dry season income (crop not specified).

Supporting adaptation

To assist in guiding efforts to deliver best practice information and appropriate support to farming households in support of their efforts to adapt to salinity, interviewees were asked to consider a range of areas in which information and/or support may be required, and how important these areas were (Table 7). All areas received an above-average rating (greater than 4.00), with the large majority of those with a salinity problem on their farm providing a rating, suggesting that farmers are likely to require information resources or support on all topics covered in the table. The most important areas involved technical information and training, reliable supply of new crop seed varieties, and suitable information on marketing and price. Infrastructure and other resources (finance and staff) were still important but received a somewhat lower mean rating.

Table 7. The importance of different areas of information and support that may be provided to farmers to assist in adaptation to salinity impacts – number of responses and mean rating, where "1" = not important at all and "7" = extremely important

Areas where information or support is required to adapt to salinity	Mean rating	Std dev	n
Technical (production) information	5.7	1.4	75
Technical training	5.6	1.5	75
Reliable supply of new seed varieties	5.6	1.2	72
Information on marketing and price	5.1	1.6	70
New infrastructure or equipment	5.0	1.8	68
Capital/financial support	4.7	1.7	70
Additional labour	4.2	2.0	71

Also on the topic of information provision, the interviewees considered a range of information sources, being asked to nominate which sources they used and how useful each source was in their efforts to adapt to salinity (Table 8). Government (e.g. DARD) was rated by interviewees whose farm was impacted by salinity as the most useful source of information on adapting the farm to salinity impacts, while neighbours and local farming groups were also highly rated sources of information. These results suggest a supportive relationship at the community level amongst farmers as they seek together to adapt to the problem of salinity, and a positive relationship with local government experts. Private companies operating in support of agriculture received the lowest mean rating score for the usefulness of information they provided, but the score was still above average (greater than 4).

Table 8. The usefulness of information sources in adapting to on-farm salinity impacts – number of responses and mean rating, where "1" = not at all useful and "7" = extremely useful

Information source	n	Mean (of 1 to 7 rating)	Standard deviation
Government (e.g. DARD)	65	6.1	0.7
Neighbours	74	6.0	1.1
Local farming group	57	5.8	1.2
Media (including social media)	59	5.5	1.4
Private extension service	56	5.4	1.6
Other family members	62	5.4	1.3
Own internet research	51	5.1	1.7
Private companies (e.g. input suppliers)	59	4.9	1.7

Neighbours or friends were the most commonly used source of information on growing dry season crops amongst the households included in the survey (Table 9). Family was the next most common source of information, while outside of personal relationships input suppliers and the media (including internet search, TV and radio) were also relatively common sources of information. The training category included extension officers, workshops, and universities. Farmer groups or co-operatives, and government, were named as information sources on dry season crops only rarely, though it is possible that these are covered by the categories of neighbours and training, respectively.

Table 9. Sources of information used by surveyed households to find out how to grow dry season crops

Source of information	n
Neighbours/friends	168
Family	58
Supplier	30

Media/online	30
Training	14
Own knowledge/experience	10
Traders	2
Farmer group/cooperative	1
Government	1

2.4 Discussion

2.4.1 Impacts of salinity

The results indicate that most farming households rely on water from canals, rivers, or irrigation canals. The heavy reliance on natural water sources from irrigation canals and rivers makes farmers vulnerable to the adverse effects of saltwater intrusion. When these water sources become saline, crops suffer significant damage. This is in line with findings of Kaveney et al. (2023) that extensive salinity in rice producing areas of the VMD has led to substantial rice crop losses.

This research suggested that salinity either was not considered to be a problem in Long My district, Hau Giang province, or that its impacts were not yet noticeable to farmer respondents at the time the HHS was carried out. Either of these hypotheses might only be confirmed via soil testing at each HHS farm location, or by accessing salinity data that may already be available for the district. It is possible that the embankment system in place in this district may still be protecting farmers from noticeable salinity impacts at the time of writing.

Both surveyed districts in Soc Trang province, however, were experiencing noticeable levels of salinity as observed by respondents, despite the contention that this province's embankment system was also believed to have reduced the severity of the salinity issue for farmers. Our research suggests that salinity became a noticeable issue in Long Phu district before it became an issue in Tran De district. However, Tran De district is further downstream than Long Phu district on the Hau River. It may be that Tran De district has a more advanced embankment system to protect farmers, there may be other landscape factors that make salinity a less severe issue in this district, or farmers may be less likely to observe the problem of salinity.

Our findings confirmed earlier research (Loc et al. 2021a, Kaveney et al. 2023) that salinity is most severe in the VMD during the dry season, that is in the period from December to May. Salinity intrusion led to several negative impacts on agricultural production. Farmers reported reduced crop yields, particularly in rice cultivation, alongside a loss of farm income. These impacts contributed to an increased workload as farmers attempted to maintain productivity. These findings are consistent with earlier studies (Nguyen et al. 2020b, Kaveney et al. 2023, Thach et al. 2023, Tran & Touch 2024), which found that salinity intrusion significantly reduced rice yields and made it more difficult for farmers in the VMD to sustain their income.

2.4.2 Adapting to salinity

In saline-impacted areas such as Long Phu and Tran De districts, we might therefore expect that farmers were more likely to adapt to salinity by employing on-farm measures such as changing the crops they produce during the dry season to more saline-tolerant types (Bryan et al. 2009, Schneider & Asch 2020, Dendir & Simane 2021, Schmitt et al. 2024). Despite this expectation, relatively few farmers surveyed noted changes in the dry season crops they had grown, though as Chapter 6 discusses, many farmers were growing dry season crops in the field other than rice. This may indicate that agricultural transformation in the VMD, in response to salinity, is still in its early stages. This would be characterised by smaller-scale and localised adaptive transformation of agricultural system to respond to the issue of salinity. A similar survey several years in the future may observe much more widespread adoption of such approaches. Our research does suggest, however, that dry season crop alternatives to rice must be saline tolerant, and that there must be a suitable market for the resulting produce.

We asked farmers to consider a range of on-farm and off-farm adaptations to salinity. On average, the respondents rated as the most important adaptations increasing the amount of time they worked off-farm, and starting a new business. Both constitute income diversification measures without changing farm practices. When considered alongside the importance given to dry season fallowing and producing less on the farm, a potential shift away from farming to other means of income generation is implied. Such a shift may pose future concerns in the VMD including labour shortages for remaining farm operators and reduced food security for the region and Vietnam as a whole, given the country's reliance on the VMD as its most important food bowl.

Amongst the less effective adaptations as rated by respondents included constructing new drainage infrastructure, transitioning to non-crop farm production, improving the efficiency of growing existing crops, growing different crops in the dry season, and cultivating different varieties of the same crop in the dry season. However, these measures require a certain amount of up-front and/or ongoing investment, and this option is not likely to be available for many smallholder farmers due to their limited capital resources or access to credit.

Two other adaptation measures, growing different crops in the dry season and growing different varieties of the same crop in the dry season, were perceived as the least effective measures by farmer respondents. Although these adaptation measures were encouraged by the government and experts, they do present farmers with challenges including availability of relevant knowledge and skills to grow alternative crops. This implies that further support is needed to maximise successful adoption of non-rice dry season cropping by farmers.

Amongst our respondents experiencing salinity, there appeared to be a considerable need for information and support on adaptation across all technical, agronomic, marketing and infrastructure areas. This is likely to be related to their historic familiarity with rice production, and the relative newness of wider-scale adaptation in the form of growing alternative crops. Of the sources of information that farmers might rely on to adapt to salinity, DARD and family/social networks were the most highly rated. Private companies were less highly rated, but still given an above average score, while other stakeholders and the media were also rated relatively highly. This result does not suggest a clear pattern in terms of targeting extension delivery through certain pathways, but rather that information provision on salinity adaptation may continue to be provided through a variety of means to ensure maximum reach of the target audience.

In addition, interviewees were asked to consider which new farming practices and new sales and marketing practices may be required to support new crops. For new farming practices, items mentioned included new machinery, new fertiliser and spraying techniques, and technical information on the crops. For sales and marketing, items mentioned included a good understanding of crop pricing and promotion. In a review of crop diversification projects in a similar deltaic system in Bangladesh, the authors reported that most of the reviewed projects focused on production issues and neglected market development for new crops. Some projects recommended establishing market linkages, however, private or community-led market dynamics were often poorly understood or managed (Nandi et al. 2024).

2.4.3 Training and extension

Training and extension support is needed to help local farming household adapt to salinity, as well and demographic and value chain dynamics. Two key areas identified were production (technical) support and agribusiness support. Ideally, training and extension initiatives should incorporate Gender Equality, Disability, and Social Inclusion (GEDSI) principles, with a focus on women, youth and ethnic minorities (i.e. Khmer communities).

Production and adaptation

Farmers noted a lack of information and support regarding adaptation in saline-impacted areas of the VMD in terms of technical, agronomic, marketing and infrastructure needs. In particular, there appears to be an opportunity to improve extension delivery for successful adaptation of alternative crops in agronomic best practice; and to provide farmers with more timely forecasts and updates on the salinity status of the VMD to allow them to adjust their crop cycle planning. Extension and information delivery for alternative crops should focus primarily on field crop production, given it will usually be the main source of farm income. Suitable, best practice production information can improve farm business profitability.

To ensure maximum reach of the target audience, such information may be provided through a variety of avenues, including DARD, agronomy and input supply companies, farming groups and co-operatives. However, our research suggests that it is more likely to be trusted if the information is provided by local sources such as neighbours, friends and family. Policymakers and public agricultural extension services may consider ways to leverage these trusted private information sources and community networks for information delivery.

Provision of tailored production knowledge and training on the production of key alternative crops may help overcome reluctance to change from more traditional production systems for experienced farmers, while at the same time addressing limited production experience for these crop varieties amongst other farmers.

We found positive correlations of higher levels of household education and greater farming experience. Efforts to improve educational opportunities for all farming household members, not just those directly involved in production, could positively impact alternative crop productivity, efficiency and profitability (Mussa 2015).

Marketing and business engagement

Some research participants noted that they would like to receive training in how to sell their crop, including training in online sales (e.g. Facebook, Zalo). Case study research suggested that successful cooperative engagement with markets required effective cooperative leadership. Current or prospective cooperative leaders may be provided with leadership training to build capacity for collective and successful market engagement, in areas such as market and buyer engagement practices, coordination of cooperative production and resource sharing, and contract negotiation.

Farming families may be provided with more support in their efforts to obtain sources of off-farm income, for example by having access to business start-up training; and potentially access to low-interest business start-up loans. Such business opportunities in the VMD will exist inside the agricultural sector (for example, crop input supply or produce trading; agronomy or advisory roles; marketing; processing; but also in other sectors of the regional economy.

The research indicated a relative lack of training and local capacity in agribusiness and entrepreneurship, with institutional skills and knowledge gaps noted for government agencies in the VMD. There is an emerging role for smaller private sector and civil society organisations involved with facilitating business start-ups. Many of these could be linked to formal institutions such as universities and district and commune level government agencies.

2.5 Conclusions

Salinity has limited the productive capacity of considerable areas of land that have historically been dedicated to year-round production of rice in the VMD, and is expected to become more pronounced in the future. This is especially a problem in the dry season when saline intrusion is most significant.

This research suggested that salinity either was not considered to be a problem in Long My district, Hau Giang province, or that its impacts were not yet noticeable to farmer respondents at the time the HHS was carried out. Both surveyed districts in Soc Trang province, however, experienced noticeable levels of salinity, becoming a noticeable issue in Long Phu district before it became an issue in Tran De district.

Our findings also confirmed earlier research that salinity is most severe in the VMD during the dry season, that is in the period from December to May. Many of the farmers we surveyed who considered themselves to be experiencing the impacts of salinity recognised three notable impacts on their farm and in their district: reduced crop yield; loss of farm income; and the need to work the land more intensively to maintain its level of productivity.

In saline-impacted areas such as Long Phu and Tran De districts, we might therefore expect that farmers were more likely to adapt to salinity by employing on-farm measures such as changing the crops they produce during the dry season to more saline-tolerant types. Nonetheless, relatively few farmers surveyed noted changes in the dry season crops they had grown. This may indicate that agricultural transformation in the VMD, in response to salinity, is still in its early stages.

We asked farmers to consider a range of on-farm and off-farm adaptations to salinity. On average, the respondents rated as the most important adaptations increasing the amount of time they worked off-farm, and starting a new business. Both constitute income diversification measures without changing farm practices. When considered alongside the importance given to dry season fallowing and producing less on the farm, a potential shift away from farming to other means of income generation is implied. Such a shift may pose future concerns in the VMD including labour shortages for remaining farm operators and reduced food security for the region and Vietnam as a whole, given the country's reliance on the VMD as its most important food bowl.

Some adaptation measures that were considered less effective included constructing new drainage infrastructure, transitioning to non-crop farm production, improving the efficiency of growing existing crops, growing different crops in the dry season, and cultivating different varieties of the same crop in the dry season. However, these measures require a certain amount of up-front and/or ongoing investment, and this option is not likely to be available for many smallholder farmers due to their limited capital resources or access to credit.

Growing different crops in the dry season and growing different varieties of the same crop in the dry season, were perceived as the least effective adaptation measures. Although these adaptation measures were encouraged by the government and experts, they do present farmers with challenges including availability of relevant knowledge and skills to grow alternative crops. This implies that further support is needed to maximise successful adoption of non-rice dry season cropping by farmers.

Amongst our respondents experiencing salinity, there appeared to be a considerable need for information and support on adaptation across all technical, agronomic, marketing and infrastructure areas. This is likely to be related to their historic familiarity with rice production, and the relative newness of wider-scale adaptation in the form of growing alternative crops. Of the sources of information that farmers might rely on to adapt to salinity, DARD and family/social networks were the most highly rated. Information provision on salinity adaptation may continue to be provided through a variety of means to ensure maximum reach of the target audience.

Farming households in the VMD require training and extension support to adapt to salinity challenges, focusing on production/technical support and agribusiness development. Such support should endeavour to incorporate GEDSI principles for women, youth, and ethnic minorities. Farmers lack information on alternative crop production, timely salinity forecasts and marketing strategies. While extension services can deliver information through various channels, farmers trust local sources like neighbours and family most. Training needs include alternative crop production techniques, digital marketing skills, and cooperative leadership development. Supporting off-farm income opportunities through business training and low-interest loans could diversify household income. Significant capacity gaps exist in agribusiness and entrepreneurship within government agencies, creating opportunities for private sector and civil society organisations to provide support through partnerships with universities and local government.

Chapter 3. Determinants of adaptation strategies to saline intrusion among upland-crop farmers in a coastal province in Vietnam

Tran Thi Thu Duyen, Paul Kristiansen, Michael Coleman, Huynh Viet Khai and Le Thanh Sang

3.1 Introduction

Agriculture plays an important role in Vietnam's economic development, ranking second in Southeast Asia and fifteenth globally in terms of agricultural product exports. With a total export turnover of agricultural, forestry, and fishery products reaching 27.88 billion USD in the first six months of 2022, an increase of 13.9% over the same period in 2021 (Do 2022), the sector's significance is undeniable. However, climate change has cast a shadow over this crucial industry, reducing arable land, inducing drought and saline intrusion, and exacerbating pest infestations, posing a significant challenge to its continued productive growth.

The Vietnamese Mekong Delta (VMD) is a key economic region renowned for its fertile plains, abundant water resources and highly favourable tropical climate, making it a hub for agricultural production. However, in recent years, the region has suffered from the detrimental effects of climate change, notably the worsening issue of saltwater intrusion (Vu et al. 2018). This phenomenon has disrupted agricultural activities, leading to a scarcity of fresh water for production, thereby damaging rice and crop yields and, consequently, impacting farmer incomes (Tran & Cook 2024).

Soc Trang, a coastal province within the VMD, is particularly susceptible to climate change and sea-level rise (Tamura et al. 2018). Farmers in this province face numerous difficulties and challenges in cultivating crops under these unfavourable conditions, with Long Phu and Tran De districts bearing the brunt of saltwater intrusion. To address these challenges, this chapter delves into farmer adaptation strategies in response to saline intrusion in Soc Trang province, aiming to propose solutions that enhance their ability to cope with this environmental stressor.

The factors that may be expected to influence farmer decision-making regarding these adaptation strategies include household demographic characteristics (Ojo & Baiyegunhi 2020), farm characteristics, weather conditions (Tran et al. 2019, Tan et al. 2020) and financial factors (Bedeke et al. 2019, Tran et al. 2019). Household demographic characteristics considered in this research include education, age and household size. The respondents with higher education may have better knowledge in managing salinity-related challenges, potentially influencing their adaptation choices. The respondent's age may reflect their experience and knowledge in managing salinity-related challenges, potentially influencing their adaptation choices. The total number of people in the household may influence the household's labour resources and income needs, potentially affecting the adoption of certain adaptation strategies. Farm characteristics considered here include well access and land impacted by salinity. Access to a well as an alternative water source may be crucial during periods when canal water becomes unsuitable for irrigation due to salinity intrusion, potentially influencing adaptation choices. The proportion of land affected by salinity may influence the severity of income losses and the need for adaptation strategies, as more extensive salinity impacts may necessitate more intensive adaptation measures. The weather condition considered here is dry season water quality. The quality of water in terms of salinity during the dry season directly impacts the suitability of water for irrigation and crop production, potentially influencing the adoption of specific adaptation strategies. Finally, the financial factor considered here is off-farm income (Bedeke et al. 2019, Ojo & Baiyegunhi 2020). Having off-farm income sources may provide a financial cushion during periods of reduced agricultural income due to salinity intrusion, potentially impacting the need for specific adaptation strategies.

3.2 Methodology

3.2.1 Study site and sampling approach

The study was carried out in Long Phu district and Tran De district (Soc Trang province), using a household survey (HHS). A relatively limited proportion of agricultural households were found to rotate rice with other crops (the latter being the focus of the HHS) in the research area. Farmers were generally found to leave their ground to fallow during the dry season rather than take an opportunity to grow other crops, and during this time to take other forms of employment. As a result, the research team needed to use a non-probability sampling technique (Galloway 2005) that involved identifying and then surveying those farming households growing non-rice dry season crops.

3.2.2 Data collection

The household survey was completed using the KoboToolbox data collection suite, chosen because of its cost-effectiveness, and team familiarity with this system compared to other similar tools such as Survey Monkey and Qualtrics. Data were collected by enumerators using tablet devices, and completed surveys were uploaded automatically to the KoboToolbox server to eliminate the need for data entry. To facilitate involvement in the survey instrument design by Australian team members, and in support of human research ethics approval, the instrument was initially designed in the English language. Once finalised, it was translated into Vietnamese and established as a KoboToolbox survey form for implementation in the field. Human research ethics approval for the research was obtained from the University of New England (HE22-004) in February, 2022.

Data collection for this study took place between July 12th and August 30th, 2022, in the Long Phu and Tran De districts of Soc Trang province, Vietnam. A total of 204 farmers were interviewed in person, with each interview lasting approximately 45-50 minutes. Enumerators visited farmers either at their homes or in their fields, recording the location of each farm using GPS coordinates. Strict adherence to government COVID-19 safety protocols, including mask-wearing, social distancing, and the use of hand sanitiser, ensured the safety of both interviewers and participants throughout the data collection process.

3.2.3 Data analysis

Drawing upon the work of Lin et al. (2005), a multivariate probit model was employed to investigate the adaptation strategies adopted by farmers in response to saline intrusion. This econometric model is characterised by a set of n binary dependent variables y_i, representing whether a farmer had adopted a particular strategy among *m* types of saline intrusion adaptation strategies. The vector *x* denotes a set of explanatory variables, $\beta_1, \beta_2, \ldots, \beta_n$ are conformable parameter vectors. The random error terms $\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_n$ are distributed as a multivariate normal distribution with zero means, unitary variance, and an *n x n* contemporaneous correlation matrix R = $[\rho_{ij}]$, with density $\emptyset(\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_n; R)$,

$$y_i = \begin{Bmatrix} 1 \ if \ x'\beta_i + \ \varepsilon_i > 0 \\ 0 \ if \ x'\beta_i + \ \varepsilon_i \ \leq 0 \end{Bmatrix}$$

Table 10 presents the independent variables included in the multivariate probit model. The dependent variables capture the adaptation strategies adopted by farmers in response to saline intrusion, namely:

- Growing different crops/different varieties in dry season: this variable indicates whether farmers adopt crop switching or variety selection as an adaptation strategy to cope with salinity stress during the dry season.
- Starting a business to diversify household income sources: this variable captures whether farmers initiate non-farm business ventures to supplement their agricultural income and mitigate the financial impacts of salinity intrusion.
- Increasing time working off-farm: this variable indicates whether farmers dedicate more time to off-farm employment opportunities as a means of compensating for reduced agricultural income due to salinity effects.

Table 10. Independent variables in the multivariate probit model

Variables	Definition
Dependent variables	
Grow different crops/ different varieties in dry season	1= farmers grow different crops/ different varieties in dry season; 0 = others
Start business to diversify household income sources	1 = farmers start business to diversify household income sources; 0 = others
Increase time working off-farm	1 = farmers increase time working off-farm; 0 = others
Independent variables	
Education	1 = farmer's education is junior high school and above; 0 = others
Age	Age of respondent (years)
Household size	Total number of people in the household
Off-farm income	Household's off-farm income (VND million)
Well access	1 = farmers have a water well; 0 = others
Dry season water quality	Water quality in terms of salinity in dry season, from 1 to 7 (1 = very poor quality; 4 = neutral; 7 = very high quality)
Land salinity impact	Proportion of land impacted by salinity (% of household farmed land)

3.3 Results

Table 11 shows the results of multivariate probit regression to identify the factors affecting farmers' adaptation strategies to the current situation of salinity intrusion.

In model (1), "changing crops/varieties in the dry season", three variable coefficients are statistically significant: off-farm income, well access, and water quality in the dry seasons. The off-farm income variable has an impact on the implementation choice of farmers and has a positive relationship with farmers choosing to implement the crop change model in the dry season. The coefficient of the dry season water quality variable has a positive sign, which is consistent with expectations.

Table 11. Multivariate probit estimation. Note: Likelihood ratio test of rho21 = rho31 = rho32 = 0; chi2(3) = 6.77122 Prob > chi2 = 0.0796

Variable	(1) Different crops/varieties		(2) New business		(3) Working off-farm	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Education	-0.133	0.465	-0.019	0.402	-0.650*	0.392
Age	0.031	0.022	-0.056***	0.020	-0.038**	0.019
Household size	0.077	0.218	-0.615***	0.225	-0.553***	0.187
Off-farm income	0.005*	0.003	0.006**	0.003	0.004*	0.003
Well access	1.473***	0.548	-0.269	0.578	-0.156	0.678
Dry season water quality	0.400*	0.222	0.020	0.212	-0.027	0.203
Land salinity impact	0.009	0.008	0.011*	0.006	0.014**	0.006
Constant	-5.082***	1.711	3.442**	1.579	2.436*	1.348
rho21	-0.256	0.327				
rho31	-0.694***	0.219				
rho32	-0.191	0.317				
Observations	78					

In model (2), “starting a new business to diversify household income sources”, four variable coefficients are statistically significant, including age, household size, off-farm income, and land impacted by salinity. The coefficient of age is statistically significant and has a negative sign, suggesting that younger farmers tend to choose this strategy maybe because they are more active. Household size also has a negative affected on the choice of this strategy. The coefficient of the off-farm income variable is statistically significant at the 5% level, has a positive sign and is positively related to the side business strategy, meaning that when farm households have off-farm income, the ability for them to carry out other forms of business activity to diversify income sources will be higher than farmers who do not have off-farm income. Finally, the coefficient of land impacted by salinity is statistically significant and has a positive sign. This means that the more the land is affected by salinity, the greater the probability of a farmer choosing this strategy.

In model (3), “increasing off-farm working time”, five variable coefficients are statistically significant, including education, age, household size, off-farm income, and land impacted by salinity. The coefficient of education is statistically significant and has a negative sign, suggesting that lower educated farmers tend to choose this strategy because some activities such as handicrafts production, bamboo weaving, basket weaving, mat weaving, and working for shrimp processing companies do not require a high education level. The coefficient of age is statistically significant and has a negative sign, suggesting that younger farmers may tend to choose this strategy because they are more physically active. Household size was also negative related to the choice of this strategy. The coefficient of the off-farm income variable is statistically significant at the 5% level, with a positive sign. Finally, the coefficient of land impacted by salinity is statistically significant and has a positive sign. This means that the more the land is affected by salinity, the greater the probability that a farmer may choose this strategy.

3.4 Discussion

The research results show that the strategy of "changing crops/varieties in the dry season" is affected by three factors, including off-farm income, well access, and water quality in the dry seasons. In fact, farmers with diverse sources of income will have relatively stable financial resources, and can therefore choose from among more types of crops to adapt to saline intrusion to a greater extent than farmers with only one income source from agriculture. Households that only receive income from agriculture will have more risks in terms of capital, so changing crops will have a much greater negative effect on the household's overall income if the new crop does not bring the expected results. This result is in line with previous research (Bedeke et al. 2019, Ojo & Baiyegunhi 2020) that if a farmer has off-farm income, he or she is more likely to choose an on-farm adaptation strategy. Water is an indispensable input in farming. The quality of irrigation water affects the quality of crops (Tan et al. 2020). In the dry season, the quality of irrigation water was rated as good by respondents, meaning that saline levels in irrigation water were low and hence farmers could continue to grow crops. If water quality is low, farmers may not continue growing crops but will switch to other activities such as business and increased non-agricultural work. In addition, the coefficient of the well variable is statistically significant and positively affected the choice of this strategy, suggesting that farmers who have a well on their farm would have fresh water for crop irrigation in the dry season.

Off-farm income also positively affects the decision to increase off-farm working time. This means that when farming households have an off-farm income, they are likely to increase their working time. Off-farm activities to diversify income sources will be higher than for farm households with no off-farm income. This is consistent with the reality that when farming households carry out off-farm activities such as weaving, making wooden furniture, or other small business activities, the higher their income from these activities, the more time they will tend to spend on the work. Thus, farming households with off-farm income will be more interested in off-farm activities to diversify their income sources than households without off-farm income. This result is in line with previous research (Bedeke et al. 2019, Ojo & Baiyegunhi 2020) that if a farmer has off-farm income, he or she is more likely to choose an adaptation strategy. In contrast, farmer age negatively affects the adoption of increasing off-farm working time. Younger farmers may be more likely to choose this strategy because they are more physically and perhaps mentally active and capable. This result is in line with the findings of Ojo and Baiyegunhi (2020) who found that the higher a farmer household member's age, the less the probability of their choosing an adaptation strategy.

Off-farm income also had a positive effect on the adoption of starting a new business to diversify household income sources. In fact, to diversify income against the impact of saltwater intrusion through additional business strategies, farmers must have financial support. If a farmer's income is high, they will invest in input costs for additional business activities to improve their income. Therefore, this will be easier for households with income sources other than agriculture, and more difficult for households whose income mainly depends on agricultural production. This result is in line with earlier research (Bedeke et al. 2019, Ojo & Baiyegunhi 2020) that if the respondent has off-farm income, he or she is more likely to choose an adaptation strategy. In contrast, farmer's age has a negative effect the adoption of starting a new business to diversify household income sources. Younger farmers may tend to choose this strategy because they are more physically active. This result is in line with the finding of Ojo and Baiyegunhi (2020) that the higher the respondent's age is the less the probability of choosing an adaptation strategy.

3.5 Conclusions

This study applied a multivariate probit model to analyse factors affecting farmers' choice of adaptation strategies to the situation of salinity intrusion in farming in Soc Trang province, in order to propose solutions to help farmers adapt to this issue.

Faced with the negative impacts of salinity outlined in further detail in Chapter 2, farmers can implement a variety strategies to minimise losses. Positive adaptations carried out by farmers to improve farm business and family income efficiency include conducting business operations to diversify household income sources, increasing the amount of time worked off-farm, and changing crop types/crop varieties. These adaptations are also addressed individually in Chapter 2.

The results of an analysis, using multivariate probit regression, of the factors affecting farmer adaptation of these strategies to cope with saline intrusion in the dry season showed that:

- Adapting in the form of conducting business operations to diversify household income sources was influenced by factors such as age, household size, off-farm income, and land impacted by salinity.
- Increasing the time worked off-farm for both the head of the household and family members was influenced by several factors including education, age, household size, off-farm income, and land impacted by salinity.
- The strategy of changing crop types or varieties grown during the dry season was influenced by factors including off-farm income, well access, and water quality in the dry season.

From the above research results as well as those outlined in Chapter 2, the authors make some recommendations for local authorities:

- First, it is necessary to forecast saltwater intrusion and promptly inform farmers so they can take appropriate response measures.
- Second, local authorities need to coordinate with researchers to study and adjust production schedules to avoid drought and salinity, and produce and provide farmers with good quality seedling varieties that are better able to cope with drought and salinity conditions.
- Third, authorities should encourage and create conditions for businesses to invest in off-farm sectors to create more jobs opportunities in rural areas. In addition, they should organise vocational training for residents participating in off-farm activities. In this respect it is most likely necessary to pay the most attention to workers who are poor or who have become unemployed after working for companies.
- Finally, they should have policies on providing loans for residents to implement adaption strategies to saline intrusion.

Some recommendations for farmers are also suggested:

- First, farmers should regularly obtain up to date information about the saltwater intrusion situation in their district from newspapers, television, and the internet; as well as monitor announcements and forecasts of saltwater intrusion from local authorities to be able to make timely responses to salinity.

- Second, farmers need to follow local instructions on their planting calendar.
- Third, farmers need to proactively implement adaptation measures such as adopting alternative crops in the dry season, selecting high-quality varieties that may be better able to cope with drought and salinity, and proactively storing fresh water in the fields before saltwater intrusion occurs. If permitted by local authorities, wells should be established to provide additional water for irrigation in the dry season.
- Fourth, farmers should regularly participate in local training sessions to gain more knowledge from experts as well as learn from the experiences of other farmers to be able to select suitable adaptation measures.
- Finally, if fields cannot be cultivated due to severe drought and salinity, farmers and their family members should consider additional business activities (e.g. local craft production such as wickerwork, netting, or handmade products made from locally available materials) and/or engage in off-farm employment in a field such as agricultural product processing. Furthermore, they should actively participate in training classes and vocational training programs suited to relevant job opportunities.

Chapter 4. Farming household socio-economic characteristics

Paul Kristiansen, Michael Coleman, Le Thanh Sang and Mao Huynh Nhu

4.1 Introduction

In this chapter, we present summary demographic and economic information for the HHS respondents, including: the location of the respondents; respondent and household age, gender and household role profiles; ethnicity; educational attainment; farm experience and succession planning; household expenditure and off-farm income sources.

There are many evaluation studies in the existing literature regarding the factors influencing the willingness and capacity of farmers in the VMD to implement adaptations to climate change-related impacts such as saline intrusion and drought (see also Chapter 2 and Chapter 3 of this report). Greater *willingness* and/or *capacity* to trial and implement adaptations may be associated with previous negative experience of climate events; higher education levels and access to information; current level of food security; motivation to make change; access to finance (credit and/or savings) to support adaptation; strong local social capital (peer and family networks, community organisations); and capacity to change within institutional and policy frameworks (Trong 2016, Gong et al. 2018, Phuong et al. 2018b, Hoan et al. 2019, Nguyen et al. 2019, Martins & Gasalla 2020).

On the other hand, farming families who are relatively unwilling or unable to adapt to climate change impacts may be motivated by: lack of previous experience of climate change impacts; relatively small land area (lack of economy of scale to adopt); limited diversity of income sources as well as access to finance (credit, savings) to support adaptation; limited labour resources; limited knowledge of non-rice alternatives; relatively weak local social capital; and unwillingness to abandon 'traditional' rice production (Huynh & Stringer 2018, Pham et al. 2018, Hoan et al. 2019, Nguyen & Hens 2021).

The research presented in this chapter is intended to provide a background of the family farming context in the study area to inform other chapters reporting on the FOCUS household survey (HHS) and other socio-economic field research activities.

Specific aims of this chapter include:

- Identifying demographic characteristics and trends of farming families in the VMD, including the influence of ethnicity and gender.
- Assessing the relative experience of farming households with crop production.
- Determining the relative importance of off-farm income.

4.2 Methodology

Please refer to Section 2.2 for details. The methodology to collect the HHS data presented in Chapters 2, 4, 5, 6, 7 and 9 was identical.

4.3 Results

4.3.1 Survey location

The survey included 299 completed responses, in two provinces of the VMD: Hau Giang (Long My district, 95 responses) and Soc Trang (Long Phu district, 100 responses; and Tran De district, 104 responses). Table 12 provides a summary of completed interviews by location, and Figure 7 shows their locations in the study area.

Table 12. Interviewee numbers at province, district and village level (n = 299)

Province	District	Village	Count
Hau Giang	Long My	Luong Tam	43
Hau Giang	Long My	Vinh Thuan Dong	21
Hau Giang	Long My	Vinh Vien	14
Hau Giang	Long My	Vinh Vien A	15
Hau Giang	Long My	Vinh Vien Town	2
Total, Long My District, Hau Giang Province			**95**
Soc Trang	Long Phu	Chau Khanh	30
Soc Trang	Long Phu	Loi Hung	1
Soc Trang	Long Phu	Long Duc	16
Soc Trang	Long Phu	Long Phu Town	23
Soc Trang	Long Phu	Phu Huu	12
Soc Trang	Long Phu	Tan Hung	9
Soc Trang	Long Phu	Tan Thanh	9
Total, Long Phu District, Soc Trang Province			**100**
Soc Trang	Tran De	Dai An 2	15
Soc Trang	Tran De	Lich Hoi Thuong	15
Soc Trang	Tran De	Tai Van	10
Soc Trang	Tran De	Thanh Thoi An	2
Soc Trang	Tran De	Tran De	9
Soc Trang	Tran De	Vien An	33
Soc Trang	Tran De	Vien Binh	20
Total, Tran De District, Soc Trang Province			**104**

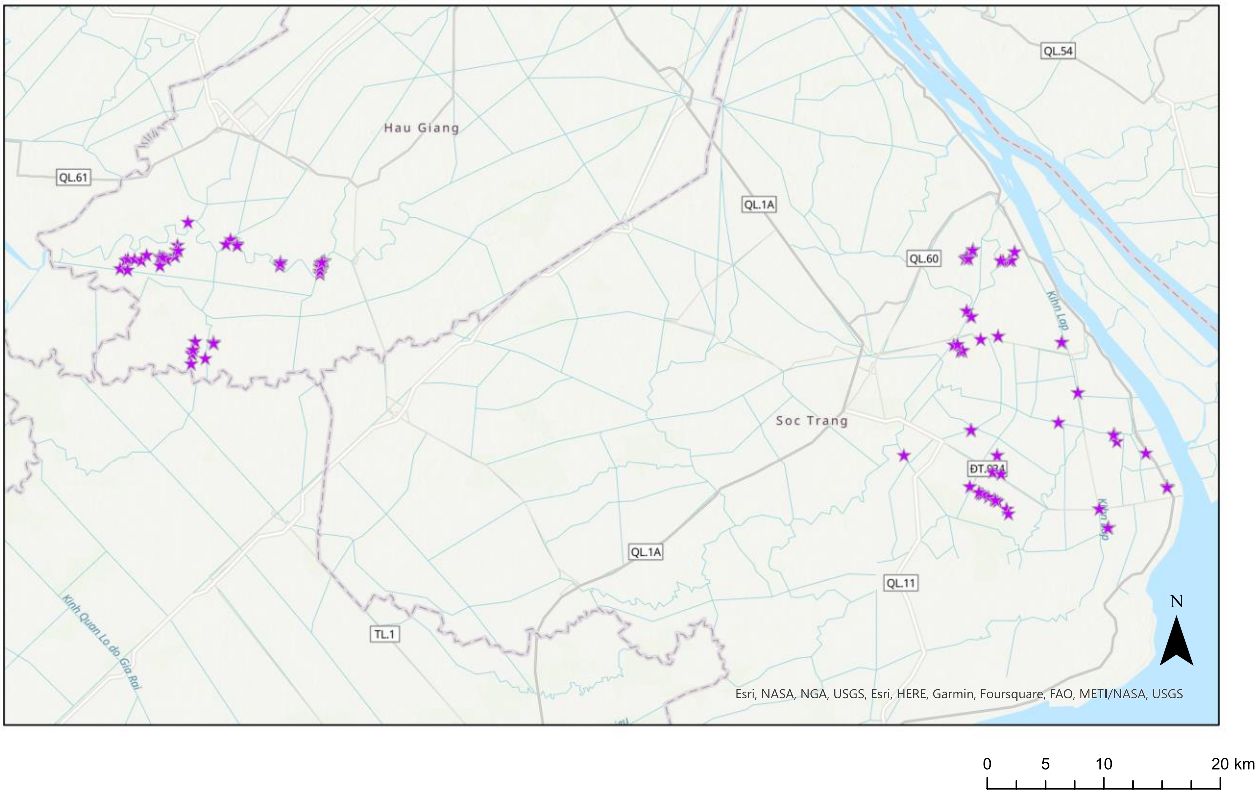

Figure 7. Map: interviewee household locations in the study area – Hau Giang and Soc Trang provinces

4.3.2 Respondent age, gender and household role

The mean age of survey interviewees (*n* = 298) was 49.9 years, with the youngest aged 20 and the oldest aged 75 (Figure 8). The majority of interviewees were male (75%). Just under 75% of interviewees considered themselves to be the head of their household, with the remainder of interviewees being other household members.

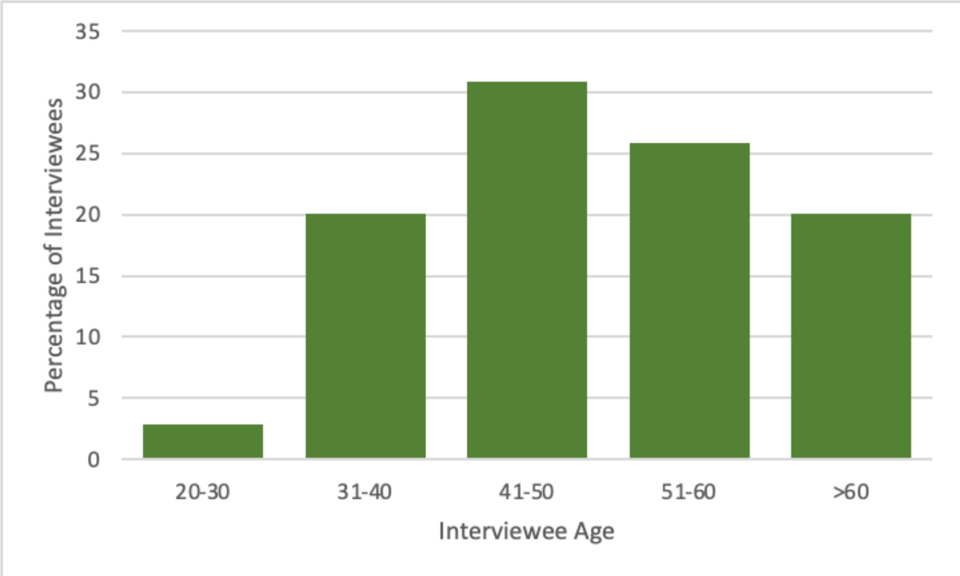

Figure 8. Age profile of interviewees (n = 298).

4.3.3 Household age and gender profile

Mean household size for all interviewees was just over 4.5 persons per household, with a minimum household size of one person and a maximum of fourteen people (std dev 1.5). Using cross-tabulation, mean household size was explored on the basis of district of residence and ethnicity. However, the results did not differ significantly based on these categories and so are not included in this report.

Across all households surveyed, the mean percentage of household population made up of different age and gender categories is shown in Table 13, Figure 9 and Figure 10. Approximately 40% of all people in the households surveyed were 30 years of age or less.

Table 13. Mean proportion of total household size represented by different age and gender categories (n = 398).

Age category	Male (%)	Female (%)	Total (%)
< 20 years	12.3	12.4	24.6
21-30 years	7.48	7.71	15.2
31-40 years	9.33	7.93	17.3
41-50 years	8.18	8.97	17.2
51-60 years	7.50	6.10	13.6
> 60 years	5.78	6.42	12.2
Total	50.5	49.5	

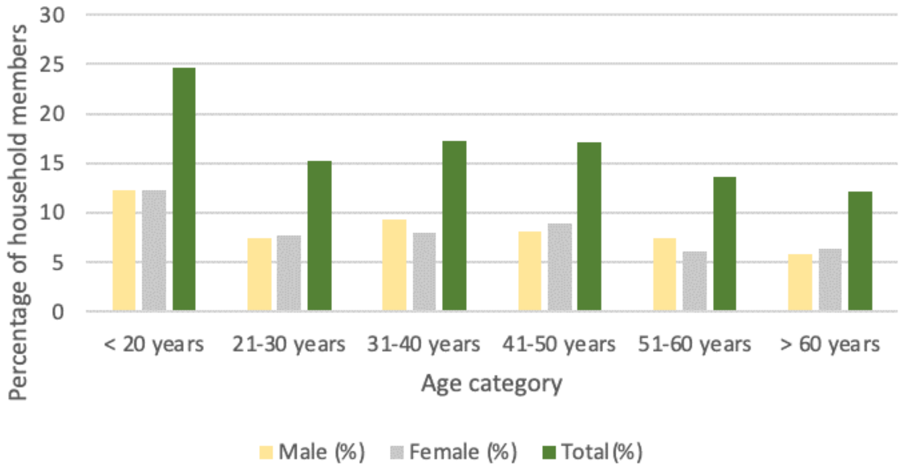

Figure 9. Mean proportion of total household size represented by different age and gender categories (n = 398).

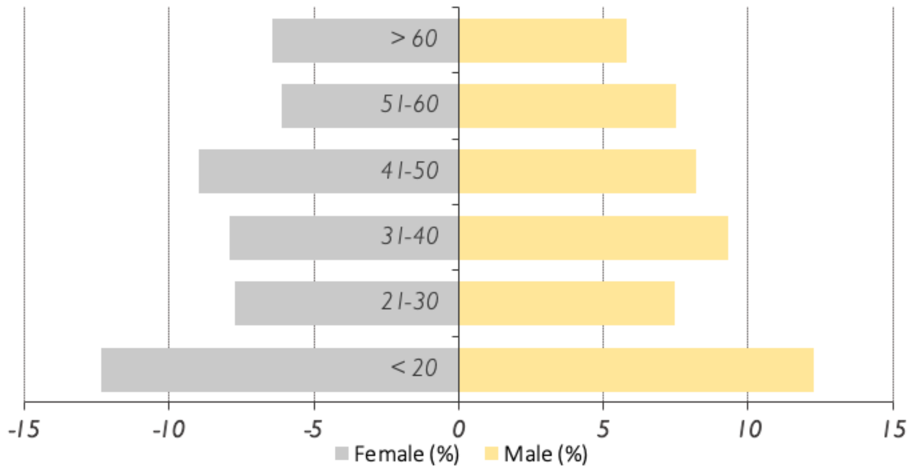

Figure 10. Population pyramid for age and gender for households included in the survey (n = 398).

4.3.4 Ethnicity

Of the 299 interviewees, 54.8% identified with the Kinh ('majority') ethnic group, 44.5% with the Khmer ethnic group, and 0.7% with the Chinese ethnic group. In 2020, the VMD had a total population of 17.37 million people. Some 40 ethnic groups reside in the VMD, with the Kinh, Khmer Chinese and Cham being the most common groups. Kinh accounted for 92%, Khmer 6.57%, Chinese 0.86%, and Cham 0.075% of the total regional population (GSO 2021).

Cross-tabulation of district of residence by ethnicity (Table 14) shows that the majority of interviewees of Long My district (Hau Giang province) were of Kinh ethnicity while the majority of interviewees of Tran De district (Soc Trang province) were of Khmer ethnicity. The split of interviewees by ethnicity in Long Phu district (Soc Trang province) was relatively even. Figure 11 illustrates these points at provincial level.

In addition to these quantitative findings, the research team conducting the HHS made a number of qualitative observations about some of the specific challenges faced by Khmer residents in Soc Trang province. These included language barriers, relatively poor access to education, and greater likelihood of remaining in a cycle of subsistence income levels and poverty.

Table 14. District of residence, by ethnicity of interviewees

District	n	Ethnicity (%)		
		Kinh	Khmer	Chinese
Long My, Hau Giang	95	98.9	0.0	1.1
Long Phu, Soc Trang	100	57.0	43.0	0.0
Tran De, Soc Trang	104	12.5	86.5	1.0

Pearson Chi-Square = 152.44; p = <0.001

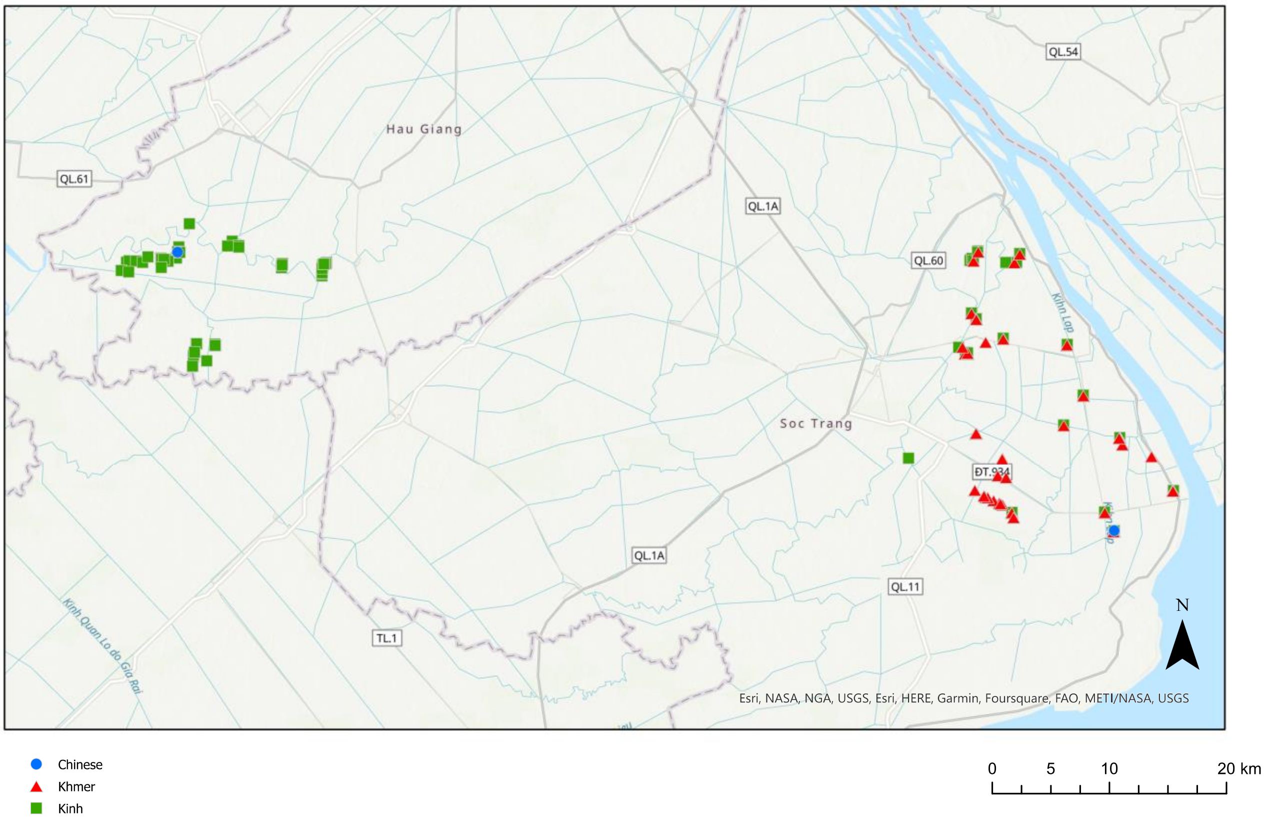

Figure 11. Map: location of interviewees by ethnicity

4.3.5 Education level

Interviewees were asked to indicate the highest level of education that any member of their household had completed (Table 15). The higher level of education found in households as a whole compared to interviewees (nearly 75% of whom considered themselves household head) suggests that the head of the household was likely to have had access to a lower level of education than other household members. Also taking into account that interviewees were just under 50 years of age, this suggests a generational divide in educational access and opportunity, where older residents of the regions surveyed (represented by household heads) have had less access to formal education than the younger members of their household in particular.

The highest level of education in the household was also cross-tabulated against district of residence (Table 17) and interviewee's ethnicity (Table 18). In both cases the results were significant:

- Household members in Hau Giang province (Long My district) were significantly more likely to have had access to higher levels of education (senior high school and university) than their counterparts in Soc Trang province (Long Phu and Tran De districts; Table 17).
- Households belonging to the Kinh ethnic group likewise have had greater access to higher levels of education than those belonging to the Khmer ethnic group (Table 18).
- The relationship of these factors is reinforced by the finding that interviewees from the Long My district were almost exclusively from the Kinh ethnic group (Table 14).

Table 15. Highest level of education of interviewee and within interviewee's household

Education Level	Interviewee (%; n = 298)	Household (%; n = 298)
Illiterate	5.7	0.7
Primary school	33.2	6.0
Junior high school (incomplete)	-	1.0
Junior high school (complete)	45.0	34.9
Senior high school	14.4	32.9
Vocational college	0.7	3.4
University	1.0	21.1

Table 16. Province of residence, by highest education level in interviewees' household

	Highest level of education in household (%)						
Province	Illiterate	Primary school	Junior high school (incomplete)	Junior high school (complete)	Senior high school	Vocational college	University
Hau Giang (n = 95)	0.0	1.1	0.0	21.1	41.1	1.1	35.8
Soc Trang (n = 203)	1.0	8.4	1.5	41.4	29.1	4.4	14.3

Pearson Chi-Square = 34.933; p = <0.001

Table 17. District of residence, by highest education level in interviewees' household

	Highest level of education in household (%)						
District	Illiterate	Primary school	Junior high school (incomplete)	Junior high school (complete)	Senior high school	Vocational college	University
Long My Hau Giang (n = 95)	0.0	1.1	0.0	21.1	41.1	1.1	35.8
Long Phu Soc Trang (n = 99)	1.0	3.0	2.0	40.4	32.3	8.1	13.1
Tran De Soc Trang (n = 104)	1.0	13.5	1.0	42.3	26.0	1.0	15.4

Pearson Chi-Square = 53.095; p = <0.001

Table 18. Ethnicity of interviewee, by highest education level in interviewees' household

	Highest level of education in household (%)						
Ethnicity	Illiterate	Primary school	Junior high school (incomplete)	Junior high school (complete)	Senior high school	Vocational college	University
Chinese (n = 2)	0.0	0.0	0.0	0.0	100.0	0.0	0.0
Khmer (n = 133)	0.8	10.5	0.0	45.9	27.8	0.0	15.0
Kinh (n = 163)	0.6	2.5	1.8	26.4	36.2	6.1	26.4

Pearson Chi-Square = 36.697; p = <0.001

4.3.6 Farm experience and succession planning

On average, interviewees had been involved in farming for approximately 23.5 years (minimum 1 years, maximum 60 years, std dev 12.9 years). The interviewees were asked to indicate who would take over the farm when they retired (Table 19). Nearly 60% of interviewees believed that their son would take over the farm, while a further 15% envisaged son/s and daughter/s taking over the farm jointly. Only 15% envisaged a daughter taking over the farm. The fact that less than 3% of interviewees either had no succession plan or intended to sell their farm highlights the strength of the farm family succession model in the VMD. The data regarding farm succession were cross-tabulated against ethnic group but the results were not significant.

Table 19. The household member/s that interviewees believe will take over the farm business when they retire

Planned farm successor	Interviewees (%; n = 296)
Son	58.4
Daughter	22.3
Son and daughter	14.9
Will sell the farm	2.4
Grandson	0.7
Childless	0.3
No plan	0.3
Sister	0.3
Son in law	0.3

4.3.7 Expenditure and off-farm income

Interviewees were asked to indicate which person/s in the household were responsible for decisions regarding household expenditure. Other than the interviewee's nominating themselves or their spouse, a range of other household members were nominated including both husband and wife jointly, parents, children, siblings, and in-laws. For ease of analysis, these latter responses were summarised into a single 'other household members' category (Table 20).

Interviewees and/or their spouse were overwhelmingly responsible for decisions regarding household expenditure, comprising in total nearly 95% of the response. These responses were cross-tabulated against district, province, ethnicity and interviewee gender to identify any significant differences. Only interviewee gender (Table 21) produced a significant difference in response and suggests that women were significantly more likely than men to take responsibility for this aspect of household management.

Table 20. Person(s) responsible for decisions about household expenditure

Person/s responsible for decisions about household expenditure	Interviewees (%; n = 299)
Interviewee	47.2
Interviewee's spouse	43.5
Both interviewee and spouse together	2.7
Other household members	6.7

Table 21. Gender of interviewee, by person/s responsible for decisions about household expenditure

	Person/s responsible for decisions about household expenditure (%)			
Gender	Interviewee	Interviewee's spouse	Interviewee and spouse together	Other household members
Male (n = 227)	38.3	51.5	3.5	6.6
Female (n = 72)	75.0	18.1	0.0	6.9

Pearson Chi-Square = 32.235; p = <0.001

Interviewees were asked to estimate the annual amounts of various sources of off-farm income obtained by all working members of the household in the last calendar year (Table 22). Many households had multiple sources of off-farm income in this period. Some 198 of the 299 households for which interviews were completed had at least one alternative source of income to supplement the income provided by the farm business. The high standard deviation for all sources of income reflects considerable variation across the households.

The data show that employment as a factory worker was both the most common form of off-farm income available to households surveyed, and provided the highest individual income source. This may suggest either that factory employment paid particularly well compared to the other forms of income covered by the survey, that factory-based jobs were relatively easily available, or perhaps that more than one member of the household worked in a factory.

The research team observed in both Hau Giang and Soc Trang province that household members may migrate to other parts of Vietnam (e.g. Ho Chi Minh City, Binh Duong province) to seek employment outside of agriculture and earn income for the household by way of remittances; but that this could result in labour shortages for farming, particularly at more labour-intensive times such as planting and harvest. The remittances “strategy” was most commonly adopted by farming household members situated on smaller areas of land (e.g. less than 10,000 m^2), and was increasingly driven by rising farm input costs and perceived risk of low yielding crops which made farming smaller land areas appear to be less economically viable. Due to their often lower levels of education, such opportunities for members of farming households most commonly included manual labour (e.g. bricklaying). In other cases, household members including farmers left the farm during the dry season (at which time the paddocks are left in a fallow state) and sought employment outside the district in non-agricultural sectors for a period of 2-3 months each calendar year, at times leaving the family home entirely vacant during this period. This allowed farmers not only to return to the farm in time to establish the next wet season crop, but also to accumulate some capital for household requirements, or to reinvest in the farm. These strategies suggest that farming (particularly on smaller areas of land) did not provide sufficient income to many households in the VMD to meet their needs or to support a desirable, upwardly mobile lifestyle.

Farm labour was also a relatively common form of income away from the household farm business (Table 11), but this appeared to be amongst the less desirable options in terms of salary amount received. Employment with government or with non-factory or farm-related ‘private businesses’ were of a similar scale in both popularity and mean annual income. It may be that on an individual basis these jobs paid more highly than employment in a factory, though the data neither supports nor refutes this suggestion. Income from contracting and land lease were both relatively rare. The data also indicated that:

- Working in businesses provided considerably more income to Kinh than Khmer households.
- Khmer households earned considerably more than Kinh households from farm labour salary.

- Households in Soc Trang earned more from farm labour and government salary sources than those in Hau Giang.
- Households surveyed in Hau Giang province earned more from employment in private businesses than those in Soc Trang.

In contrast to their household's working age members overall, it was relatively unusual for interviewees themselves to work for a salary outside of agriculture or to own a non-farming business, while farm labour a was source of income off the family farm for almost 25% of the interviewees themselves (Table 23).

Table 22. Mean and standard deviation for off-farm income sources earned by all working members of the household in the last calendar year – all interviewees' households

Off-farm income source	n	Annual income (mean) for all households (VND mil)	Annual income (standard deviation) (VND mil)
Salary (farm labour)	85	29.6	40.8
Salary (other business, e.g. shop-owners, grocery, trader)	27	67.2	61.73
Salary (factory worker e.g. garments)	113	118.2	79.7
Salary (government staff)	24	56.1	33.6
Owner of a non-farming business	18	40.3	40.4
Income from land lease	4	14.5	8.4
Contracting (e.g. harvest machinery)	3	36.7	30.1
Total household off-farm income	198	100.6	86.3

Table 23. Off-farm income generation activities in which interviewees themselves participated

Off-farm income activity	Interviewees (%; n = 299)
Salary (farm labour)	24.4
Salary (factory worker e.g. garments)	4.7
Salary (other business e.g. shop-owners, grocery, trader)	4.3
Salary (government staff)	3.3
Owner of a non-farming business	3.3
Income from land lease	2.3
Contracting (e.g. harvest machinery)	0.3

Chapter 5. Farming household typologies and successful climate change cropping systems adaptation

Paul Kristiansen, Mao Huynh Nhu, Michael Coleman and Le Thanh Sang

5.1 Introduction

5.1.1 Triple-rice production and adaptation in the VMD

The Vietnamese Mekong Delta (VMD) is critically important to Vietnam's agriculture sector, and is the location of more than half of national food production. Rice is the most significant crop in the region. It accounts for more than 90% of national agricultural exports, and serves as an essential food source and primary source of income for an estimated 18 million residents in the VMD (USAID 2022). However, the ongoing sustainability of intensive year-round 'triple-rice' production is not necessarily assured in the longer-term. This is partly a consequence of mounting climate change impacts in the region, including extreme weather events and climatic variability (UNDP & VCCI 2022) and saline intrusion and freshwater scarcity (Kaveney et al. 2023). There are also concerns regarding the negative environmental impacts of triple-rice production, including overuse of crop inputs and crop protection chemicals in an attempt to sustain declining yields (Demont & Rutsaert 2017, Stuart et al. 2018). These climatic and farm system issues have contributed to increased production costs and reduced triple-rice yields in the VMD, compromising the livelihood sustainability of smallholder farming communities, including anticipated reductions in the profitability of rice production by farmers themselves (USAID 2022, Mills et al. 2025).

In response to declining rice yields and profitability, some farming families in the VMD have exited from rice production (Mills et al. 2023, Mills et al. 2025) sought to increase off-farm work or other non-farming business opportunities (Tran et al. 2021b, Tran et al. 2023), or rented out their land or transferring land use rights to other farmers (Mills et al. 2025). Though continued production of rice alongside alternative crops, or other forms of farm system diversification, are also common responses (Le et al. 2024a). The Government of Vietnam (GoV) Resolution 120 for climate resilient-development has encouraged some farmers to adapt by implementing more diverse and less environmentally harmful farming systems (GoV 2017, Nguyen et al. 2021), including permanent transformation to fruit, aquaculture, livestock, and year-round vegetable production; crop systems diversification involving dry season vegetable production alternating with wet season rice cultivation; and rice-aquaculture systems (Tran et al. 2018, Nguyen et al. 2020b). Each of these systems may facilitate higher farm profitability and reduced reliance on farm inputs in comparison with triple-rice production (Kaveney et al. 2023), however potential risks of their adoption include market fluctuations, inadequate supply of suitably skilled labour, land unsuitability, lack of suitable irrigation infrastructure (de Janvry & Sadoulet 2019b).

Permanent transformation to fruit production and aquaculture may require substantial investment to modify production systems, and there may be legal restrictions in place in the VMD regarding such modifications (Dam et al. 2021, Le et al. 2024b). Livestock farming may similarly require significant up-front investment and specialised kills. Rice-aquaculture systems tend to be less feasible for farmers in regions with greater exposure to water scarcity, while this system involves technical production challenges including pesticide residue management, salinity control for suitable production condition to cultivate rice aquaculture especially brackish and saltwater production. Diversified rice-vegetable rotations also require considerable financial and labour investment, for example, preparing raised beds every dry season before planting the vegetable crop, as well as did land levelling for rice production in the next season (Huong et al. 2013a, Huong et al. 2014, Le et al. 2023a). Transitioning to year-round vegetable production therefore appears to be more feasible for smallholders with limited resources and capacity to change. This latter form of transformation is expected to become widespread, and is supported by a Government of Vietnam plan (Decision 467) aiming to assist struggling rice farmers to transition to annual crops, including year-round vegetable production, across nearly 50,000 hectares in the VMD.

5.1.2 The need to understand farmer heterogeneity

Farmer populations are heterogenous, involving great variation in farming system, methods of production and production system performance, socio-economic and demographic characteristics, biophysical features, farm business goals, and business management style (Vanclay 2004, Brodt et al. 2006). Farmer heterogeneity may hinder the effective design and implementation of policies and extension activities aimed at promoting widespread adoption of innovative practices, potentially leading to exclusiveness of marginalised groups such as women and youth and wasted resources, or mistargeted interventions (Vanclay 2004). Each farmer is likely to respond differently to the same drivers of change by selecting from a great range of adaptation strategy, or by utilising different pathways to achieve the same adaptation strategy (Alvarez et al. 2014, Stringer et al. 2020, Mills et al. 2025). Understanding farm population heterogeneity and its implications is therefore essential for policymakers to support transformative change with practical and locally-suitable interventions (Phuong et al. 2018a).

5.1.3 Farmer typologies and their implications for farming challenges

Uses and methods of the typology approach

Typology enables exploration of the heterogeneity within the farming sector. It have been used to characterise farmer decision making, behaviour and circumstances have been used widely to explore diversity within farming populations (Bousbia et al. 2024); to understand why farmers might respond in various ways to similar challenges (Joffre & Bosma 2009, Shukla et al. 2019, Pham et al. 2021); why they manage their farms in different ways (Rodríguez-Bustos et al. 2023); how they may react to opportunities for innovation (Daxini et al. 2019); or in what ways their information needs may differ (Vanclay 2004).

Selecting variables for typology analysis

Typology results are not only context-specific but also varied significantly depending on researchers' choices of methodological decisions and variables (Alvarez et al. 2018). There are several methods used to construct typology, including: step-by-step comparison of farm functioning; expert insights from key informants, farmers, and local experts; participatory ranking of farmer assets as ranked by the farmers themselves and by local experts; and multivariate analysis and clustering methods to statistically construct typologies from selected variables (Alvarez et al. 2014). Although most of these methods rely on some degree of qualitative information, multivariate analysis and clustering methods are often preferred (Joffre & Bosma 2009, Shukla et al. 2019, Nazari Nooghabi et al. 2020, Bâtie et al. 2022) as they more readily facilitate reproducibility (Pacini et al. 2014).

Variables used for typology analysis should capture two main components, including farming system factors; and the natural ecosystem and socio-economic context (the 'environment') to allow the research to account for both internal and external factors affecting production (Alvarez et al. 2014). Variables used in previous studies may be grouped as follows:

- Household demographic attributes such as age, gender, education, and experience in production (Bidogeza et al. 2009, Nazari Nooghabi et al. 2020, Bâtie et al. 2022, Awoke Eshetae et al. 2024).
- Farm system attributes including farm management approaches, farm size, farm area, input usage, and farm infrastructure (Bidogeza et al. 2009, Joffre & Bosma 2009, Nazari Nooghabi et al. 2020, Pham et al. 2021).
- Financial capital attributes, including savings, on-farm and off-farm income, total land managed and land ownership, infrastructure, and market access (Bidogeza et al. 2009, Sarker et al. 2021, Sinha et al. 2022, Awoke Eshetae et al. 2024).
- Biotic and abiotic stressor attributes, including salinity, drought, and water quality and quantity (Nazari Nooghabi et al. 2020).

These variables may be used to identify particular groupings of farmers (a typology) with each group featuring to some extent shared experience and knowledge, management behaviours, farmer and farm system characteristics, resource access, production challenges, and relative adaptive capacity (Alvarez et al. 2014, Siders 2019, Bartkowski et al. 2022).

5.1.4 Research objectives

Previous use of typology approaches to explore farming systems change in Vietnam, particularly in the VMD, has been limited to a few studies (Joffre & Bosma 2009, Pham et al. 2021, Bâtie et al. 2022). We therefore used a typology approach to assess the relative economic performance of different farmer cohorts who had transformed to year-round vegetable production in the VMD. In the following sections of this paper, “alternative crop” was used to refer to year-round vegetable production cultivated by former rice growers as an adaptive strategy in the VMD. Our research aims were to:

- Develop a typology of smallholder farmers adopting alternative crop production in the VMD, focusing on farmer adaptive capacity and key production challenges.
- Examine the extent to heterogeneity in farmer capacity, key production challenges, and their performance in growing alternative crop among constructed farmer typologies.
- Highlight the implications of farmer typologies and their relative performance to inform changes to farm system practices, intervention in support of alternative crop as an adaptation to climate change in the VMD.

5.2 Methodology

5.2.1 Survey design and data collection

Please refer to Section 2.2 for details. The methodology to collect the HHS data presented in Chapters 2, 4, 5, 6, 7 and 9 was identical.

5.2.2 Data processing and analysis

Cleaning of data exported from KoboToolbox was completed in Microsoft Excel, and included validation amongst enumerators and research team members, with farmers contacted by phone as necessary to confirm or correct data. Frequencies and boxplots were used to detect outliers and missing values in each column of the full dataset. Confirmed outliers and missing values were removed using the 'missMDA' package for R (Josse & Husson 2016, R Core Team 2022a).

Data analysis to classify farmer typologies used both numerical and categorical variables representing their characteristics, economic resources, farming systems, and production challenges (e.g.Bâtie et al. 2022, Awoke Eshetae et al. 2024). This study utilised factor analysis of mixed data (FAMD), followed by hierarchical clustering on principal components (HCPC) using the 'FactoMineR' and 'factoextra' packages for R (Le et al. 2008, Kassambara & Mundt 2020).

FAMD combines principal component analysis (PCA) for numerical data and multiple correspondence analysis (MCA) for categorical data, and was deemed suitable for the data analysis in this study given the mix of numerical and categorical variables in our data set (Kassambara 2017). Principal component methods, including FAMD, enhance the explanatory power of the original data by simplifying a substantial number of inter-correlated variables into a smaller set of uncorrelated variables. These uncorrelated variables are essential for creating stable and non-overlapping clusters, as they focus on the most important components while avoiding redundancy and multicollinearity (Shukla et al. 2019, Awoke Eshetae et al. 2024). Therefore, a correlation matrix was computed in R to identify highly correlated variables in the data sets. Variables have correlation values greater than 0.9 were removed from the dataset before performing FAMD (Shukla et al. 2019).

We performed FAMD twice. The first analysis determined the number of dimensions to be retained to sufficiently explain data variation, guided by the Kaiser criterion (eigenvalues greater than 1) and a total explained variation of at least 50% of the total variation (Huber et al. 2024). The final FAMD analysis used the predefined number of retained dimensions which was determined from the first FAMD analysis, with the results serving as input for HCPC.

Next, HCPC was used to perform cluster analysis by applying agglomerative hierarchical clustering to the results of FAMD. The HCPC involved four steps: computation of principal components, computation of hierarchical clustering, determination of the number of clusters based on the hierarchical tree, and application of k-means clustering to refine the results (Kassambara 2017).

After obtaining the farmer typology clustered by the HCPC, we employed overlapping 95% confidence intervals and ANOVA followed by Tukey's post-hoc test for continuous variables, as well as Chi-square and Fisher's Exact tests for categorical variables, to characterise differences among typologies.

5.2.3 Variables used for farmer typology construction

Table 24 details variables used for construction principal components in FAMD, including 19 variables categorised into four groups: demographic characteristics, economic resources, farming systems, and production challenges.

Table 24 Variables used for FAMD and HCPC analysis

Variable	Data type	Description	Unit (Labels)
Demographic characteristics			
District	Categorical	Districts of households living	Long My (Long My); Tran De (Tran De); Long Phu (Long Phu)
Gender	Binominal	Gender of respondent	Male (Male); Female (Female)
Ethnicity	Binominal	Ethnicity identification of respondent. Kinh is a major ethnicity and Khmer and Chinese are minor ethnicities in VMD	Kinh (Kinh); Khmer and Chinese (Khmer and Chinese)
Education	Binominal	Highest level of education in the household.	Below high school (HH_Below Senior); High school and above (HH_Senior & above)
Farming_exp	Numeric	Years of farming in general	Years
New_crop_exp	Numeric	Number of individual cropping seasons that farmers have cultivated new crops	Seasons
Economic resources			
Land	Numeric	Total land area owned by household	Hectares
Land_sufficiency	Categorical	Whether farm area is large enough to generate sufficient income	Enough (Yes_enough); Not enough (No_enough); Unsure (Unsure_enough)
Farming systems			

Irri_canal	Binominal	Use canal for irrigation	Use canal (Yes_canal); Do not use canal (No_canal)
Irri_well	Binominal	Use well for irrigation	Use well (Yes_well); Do not use well (No_well)
Irri_rain	Binominal	Use rain to supplement to other water sources for irrigation	Use rain (Yes_rain); Do not use rain (No-rain)
Canal_sufficiency	Binominal	Sufficiency of canal systems for irrigation	Enough canal systems (Yes_canal_enough); Not enough canal systems (No_canal_enough)
Infor_source	Categorical	Information sources used by farmers	Government agencies (Government agencies); Private companies (Private companies); Family and neighbours (Family and neighbours); Public media (Public media)
Production challenges			
Challenge_salinity	Ordinal	Farmer's self-assessed salinity challenges severity for farming productively	Rating from 1 to 7, where 1 = no challenge, 4 = neutral, and 7 = severe challenge
Challenge_freshwater	Ordinal	Farmer's self-assessed freshwater sufficient for irrigation challenge severity for farming productively	
Challenge_credit	Ordinal	Farmer's self-assessed credit access challenge severity for farming productively	
Challenge_inputs	Ordinal	Farmer's self-assessed input access challenge severity for farming productively	
Challenge_labour	Ordinal	Farmer self-assessment insufficient labour challenge severity for farming productively	
Challenge_market	Ordinal	Farmer's self-assessed market access challenge severity for farming productively	

5.2.4 Variables used to investigate performance differences of farmer typologies

For a comparative assessment of the performance of each farmer typology, we used both production scale (*Crop_area*), which measured the total alternative crop area cultivated by farmers in hectares, and financial performance indices as proxies for costs and returns. *Total_cost* included all variable costs that vary with production scale, such as inputs and (hired and family) labour expenses. *Family_labour_cost* and *Hire_labour_cost* measured the total expenses paid to family labour and hired labour, respectively. *Gross_return* measured the accounting profit received by farmers, calculated by deducting *Total_cost* from total revenue calculated from multiplying selling price and quantity, whereas *Net_return* represented the actual profit received by farmers, calculated by deducting *Total_cost* (excluding *Family_labour_cost*) from revenue. All financial variables were converted from Vietnamese Dong (VND) to United States Dollars (USD) at an exchange rate of 1 USD = 25,000 VND, and standardised to USD/hectare/month, to facilitate comparisons between different production scales and crop types.

5.3 Results

5.3.1 Factors associated with adoption of year-round vegetable cropping

Twelve outlier observations were removed from the data set as a result of data cleaning, bringing the total number of observations used in the FAMD analysis to 171 valid cases in two provinces of the Mekong Delta: Hau Giang (90 responses from Long My district) and Soc Trang (56 responses from Long Phu district and 25 responses from Tran De district).

The FAMD results illustrate the contribution of variables (and their categories) related to farmer characteristics (including demographic, economic resources), their farm systems, and their vulnerability to challenges to the first two dimensions. The levels of variable contribution were colour-coded ranging from red (low) to green (high).

Figure 12 shows the correlation between quantitative variables and the first two dimensions, as well as their contribution to each dimension. Arrows that are together are likely to be positively correlated, whereas perpendicular arrows suggest no correlation, and oppositely pointed arrows denote for negatively correlated. A longer arrow indicates higher contribution to the first two principal components.

The results show that challenge-related variables (the green and yellow arrows in the top right quadrant of Figure 1) contributed more to total variance captured by the first two dimensions compared to farmer experiences in general farming or land area owned. A positive correlation was found among several challenge-related variables, including access to markets, inputs, credit, salinity, and freshwater sufficiency, but excluding the labour challenge variable.

Farmers with larger land parcels were also more likely to be experienced in both general farming experience and specific experience in growing alternative crops, as indicated by the observed positive correlation of these variables in the top left quadrant of Figure 1. Those farmers were also more likely to face to challenge in labour insufficiency than other challenges.

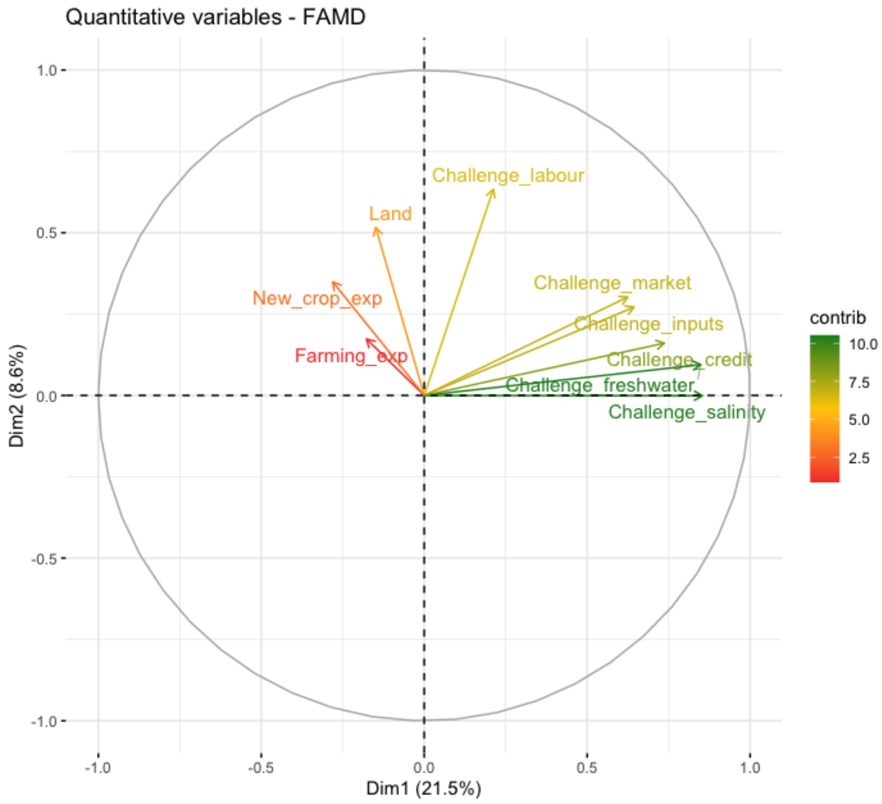

Figure 12. FAMD bi-plot for quantitative variables and their contributions to the first two dimensions depicted in vectors, ranging from low (red) to high (green) contributions

Figure 13 shows contributions of qualitative variables ranging from low (red) to high (green) contributions to the first two dimensions, with each category presented as points. Points close together were more likely to be correlated within the data. There were three highest-contributing categories (green) to the first two dimensions, representing insufficiency of canal systems for irrigation, other ethnicities (Khmer and Chinese), and Long My district. Three associations that were observed close to highest-contributing categories (green), representing insufficiency of canal systems for irrigation, other ethnicities, and Long My district. The first observed correlation (in the top left quadrant of Figure 2) comprised male farmers in Long My who were, had higher levels of household education, and reported having sufficient income. They used rain or canal irrigation for their farm and perceived that canal systems in their area were sufficient for irrigation. The second group of associations (in the bottom right quadrant) includes farmers identifying with minority ethnic groups in Tran De, including Khmer or Chinese, predominantly female, using wells for irrigation, and who perceived their land to be insufficient to generate enough income for their households. The final group of association (in the top right quadrant) involved farmers from Long Phu, who considered that canal systems were insufficient for irrigation.

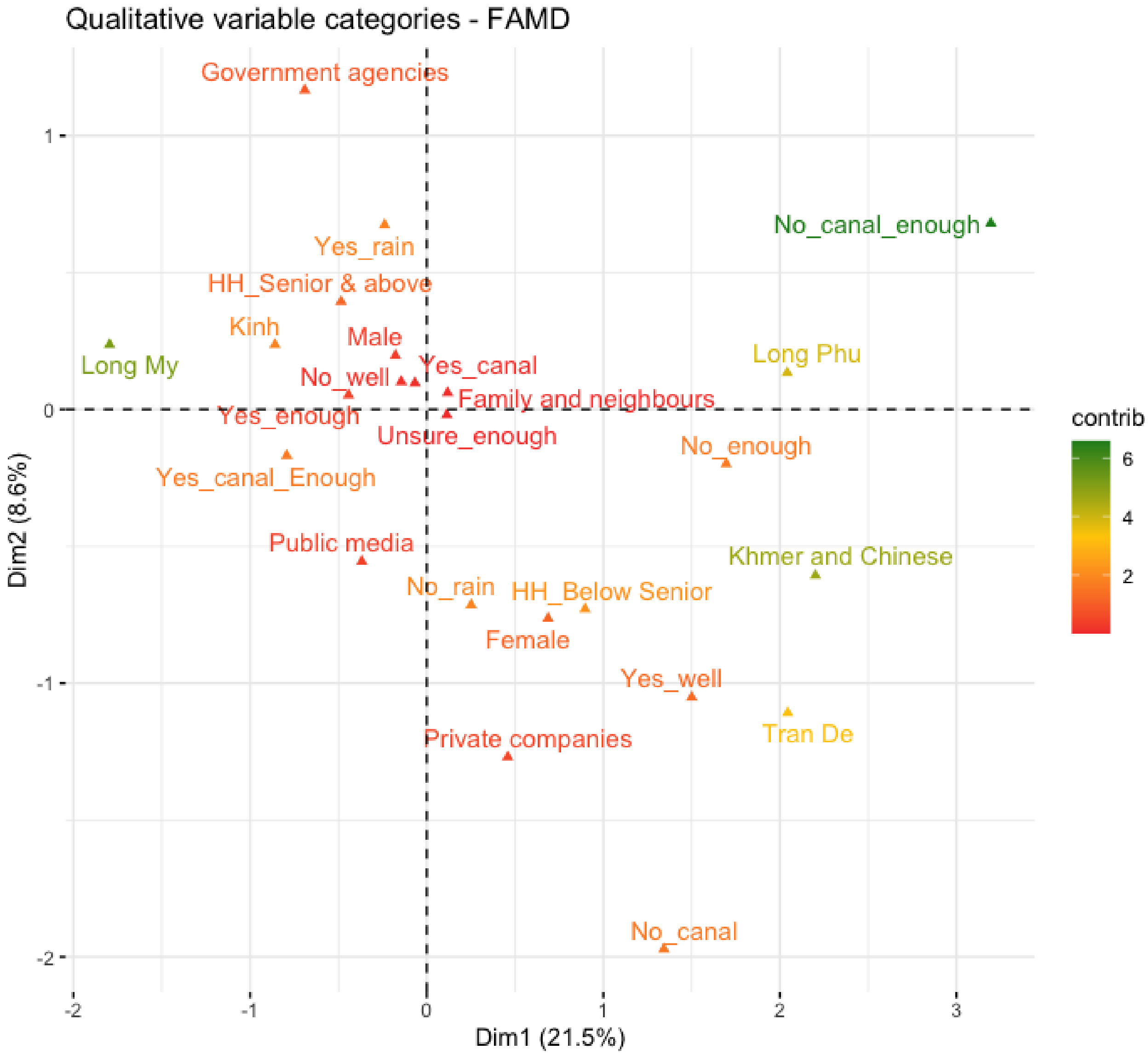

Figure 13 FAMD bi-plot for qualitative variables presented as categories and their contributions to the first two dimensions, ranging from low (red) to high (green) contributions

5.3.2 A typology of farmers adopting year-round vegetable production

Using the FAMD results we constructed farmer typologies by using HCPC. We retained the first seven dimensions which have Eigenvalue value exceeding one as suggested by the Kaiser criterion (Kassambara 2017). The seven dimensions (principal components) explained a cumulative 60.9% of the total variance for the next step of typology analysis using HCPC, with 21.5% and 8.6% of the total variance explained by dimension 1 and 2, respectively.

The clustering (HCPC) used FAMD output, identified three clusters: Cluster 1 (*Most resilient farmers*) consisted of 92 farmers, representing 53.8% of the total respondents; Cluster 2 (*Moderately resilient farmers*) included 53 farmers, accounting for 31% of total respondents; and

Cluster 3 (*Least resilient farmers)* comprised 26 farmers, comprising 15.2% of the respondents (Table 25). This table also presents details of each Cluster (farmer typology) through proportion, mean and 95% confidence interval. It also shows the results of statistical tests used to assess differences among clusters, including ANOVA, Chi-square, and Fisher's Exact tests. There were no statistically significant differences in general farming experience, and usage of information sources among farmers in the three clusters. However, amongst the other variables related to economic resources, production challenges, and farming systems, there were a range of statistically significant differences among the clusters.

Table 25. Proportion, mean, 95% confidence interval of variables within each cluster, along with statistic tests for differences in means and proportions of across clusters. See Table 1 for a full description of the variable names used here for Demographics, Farming system, Challenges.

Variables	**Cluster 1** ***Most resilient farmers (n=92)***	**Cluster 2** ***Moderately resilient farmers (n=53)***	**Cluster 3** ***Least resilient farmers (n=26)***	**Test (P value)**
Demographics				
Districts				
Long Phu (%)	2.2	62.3	73.1	
Tran De (%)	0.0	35.8	26.9	Chisq (<0.001)
Long My (%)	97.8	1.9	0.0	
Gender (% Female)	17.4	18.9	34.6	Chisq (0.006)
Ethnicity (% Kinh)	97.8	45.3	34.6	Chisq (<0.001)
Education (% High school+)	77.2	50.9	50.0	Chisq (<0.001)
Farming_exp (years)	24.0 ± 2.3	22.7 ± 3.7	19.3 ± 4.1	Non-significant
New_crop_exp (seasons)	12.2 ± 1.3^{a}	9.4 ± 2.1^{a}	6.9 ± 2.0^{b}	ANOVA, sqrt (<0.001)
Economic resources				
Land (Hectares)	1.6 ± 0.2^{a}	1.5 ± 0.4	1.2 ± 0.4^{b}	ANOVA, log (<0.001)
Land_sufficiency				
Enough (%)	85.9	60.4	57.7	
Not enough (%)	7.6	26.4	42.3	Chisq (<0.001)
Unsure (%)	6.5	13.2	0	
Farming system				
Irri_canal (% used)	98.9	86.8	100	Fisher's Exact (0.004)
Irri_well (% used)	2.2	22.6	3.8	Chisq (<0.001)
Irri_rain (% used)	65.2	18.9	69.2	Chisq (<0.001)
Canal_sufficiency (% yes)	100	73.6	23.1	Chisq (<0.001)
Infor_source				
Government agencies (%)	8.7	7.5	3.8	
Private companies (%)	2.2	7.5	3.8	Non-significant
Family and neighbours (%)	72.8	73.6	76.9	
Public media (%)	16.3	11.3	15.4	
Challenges (rating: 1-7)				
Challenge_salinity	1.4 ± 0.1^{a}	5.0 ± 0.5^{b}	5.9 ± 0.4^{b}	ANOVA (<0.001)
Challenge_freshwater	1.3 ± 0.1^{a}	4.0 ± 0.6^{b}	5.8 ± 0.4^{c}	ANOVA, log (<0.001)
Challenge_credit	1.4 ± 0.2^{a}	2.2 ± 0.3^{b}	3.9 ± 0.5^{c}	ANOVA, sqrt (<0.001)
Challenge_inputs	1.2 ± 0.1^{a}	1.7 ± 0.3^{a}	3.9 ± 0.7^{b}	ANOVA, log (<0.001)
Challenge_market	1.5 ± 0.2^{a}	1.8 ± 0.3^{a}	4.5 ± 0.6^{b}	ANOVA, log (0.001)
Challenge_labour	3.8 ± 0.5^{a}	3.4 ± 0.5^{a}	5.4 ± 0.6^{b}	ANOVA (<0.001)

Note: [a,b,c] different letters denote significant difference at the 5% level;

Cluster 1 (Most resilient farmers)

Given the relative adaptive capacity, reflected in socio-economic advantages and less severe production challenges, evident amongst members of this cluster, we have identified this cluster as *Most resilient farmers*. It was dominated by farmers in Long My district and the Kinh ethnic group who were male and with 77.2% of the group having a highest level of education in the household at high school level or above. These farmers also had the most experience growing crops of the three clusters, with an average of 12.2 seasons.

Their total land area was significantly larger than that of farmers in Cluster 3, with an average of 1.6 hectares per cluster member. Compared with the other clusters, a higher proportion of farmers in this cluster (85.9%) reported their farmland was sufficient to generate household income.

This cluster was dominated by farmers who relied on canal systems for irrigation (98.9%), however more than half also relied on rainwater to supplement to other sources for irrigation (65.2%). Only 2.2% of respondents used wells for irrigation. Notably, all farmers in this cluster considered their current canal systems adequate to meet their irrigation needs.

Respondents in this cluster reported the challenges related to salinity, freshwater sufficiency, and economics (including access to credit, markets, and farm inputs) to be less severe for them compared with farmers in the other two clusters. They considered themselves to face moderate labour-related challenges.

Cluster 2 (Moderately resilient farmers)

Due to the moderate adaptive capacity, and the severity of production challenges, we have labelled this second cluster *Moderately resilient farmers.*

Members of this cluster were from Long Phu and Tran De districts. The majority were male, and just under half identified Kinh. Approximately half had household members with high school education or above. Their average total land area was 1.5 hectares. On average, they had 9.4 seasons of experience in growing alternative crops, significantly higher than farmers in the *Least resilient farmers* cluster (discussed below).

60.4% of the farmers in this cluster perceived their current land availability as large enough to generate sufficient income. However, this proportion was significantly lower than that of *Most resilient farmers* cluster.

Canals were the predominant source of irrigation water for farmers in this cluster (86.8% of cluster members). 22.6% of members in this cluster reported relied on wells for irrigation while only 18.9% used rainwater as a supplementary source. The majority of farmers (73.6%) indicated that the current canal system in their area was sufficient for their irrigation needs.

Farmers in this cluster appeared to consider themselves to have relative difficulty with both salinity and availability of sufficient fresh water. These challenges were significantly more severe than those experienced in the *Most resilient farmers* cluster, but less severe than those in the *Least resilient farmers* cluster. Farmers in this cluster rated credit access as a less severe challenge compared to salinity or freshwater access. Their severity rating was higher significantly than that of respondents in the *Most resilient farmers* cluster but lower than in the *Least resilient farmers* cluster. In contrast, they considered market and input access to be relatively unimportant challenges, with scores of 1.7 and 1.8, significantly lower than those in the *Least resilient farmers* cluster. The labour insufficiency challenge received an average score of 3.4 points, significantly lower than the *Least resilient farmers* cluster.

Cluster 3 (Least resilient farmers)

As a result of the relative social disadvantage, insufficient access to infrastructure and resources, and challenges faced, we have labelled this cluster the *Least resilient farmers*.

Members in this cluster were predominantly of Khmer and Chinese ethnicity and from Long Phu and Tran De. As with the *Moderately resilient farmers* cluster, approximately half of the respondents had household members with high school education or above, significantly less than the *Most resilient farmers* cluster. They had the least average experience in growing alternative crops (6.9 seasons) compared to members of the other two clusters.

The total land area owned by farmers in this cluster (average of 1.2 hectares) was significantly lower than that of farmers in *Moderately resilient farmers* cluster, and considered insufficient by nearly half of the farmers.

All farmers in this cluster used canals for irrigation, though over 70% reported that the canal infrastructure in their region was insufficient for irrigation. Rainfall served as an additional irrigation source for over two thirds of respondents from this cluster, while less than 5% of respondents sourced irrigation water from wells.

On average, farmers in this cluster indicated all of the environmental, business, marketing and labour challenges of production covered in the survey to be relatively severe compared with the other two clusters. Salinity, freshwater, and labour insufficiency were particularly important challenges within this cluster, indicated by the highest scores compared to those in the other two clusters.

5.3.3 Differences in farm economic performance between clusters

Table 26 shows that members of the *Most resilient farmers* cluster cultivated, on average, approximately three times the area of alternative crops farmed by those in the other two clusters. No differences in total production costs were found between members of the *Moderately resilient farmers* and *the Least resilient farmers.* However, the average production cost for members in the *Most resilient farmers* cluster (1,115 USD/hectare/month) was significantly lower than this cost for respondents of the *Moderately resilient farmers* cluster (1,768 USD/hectare/month) and *Least resilient farmers* cluster (1,854 USD/hectare/month).

Both family and hire labour costs in the *Most resilient farmers* cluster (an average of 38.0 and 11.7 USD/hectare/month, respectively) were significantly lower than in the *Moderately resilient farmers* cluster (92.7 and 39.9 USD/hectare/month, respectively). While the average of family labour costs in the *Most resilient farmers* cluster also were found significantly lower than in the *Least resilient farmers* cluster (108.4 USD/hectare/month), no significant difference was found in hire labour cost between the two clusters. Despite these cost differences, no significant differences were found in gross return or net return among the three clusters.

Table 26. Proportion, mean, 95% confidence interval of variables within each cluster, along with statistic tests for differences in means and proportions of across clusters.

Variables	**Cluster 1 Most resilient farmers**	**Cluster 2 Moderately resilient farmers**	**Cluster 3 Least resilient farmers**	**Test (P value)**
Sample size (n)	92	53	25	
Crop_area (hectares)	0.6 ± 0.14[a]	0.2 ± 0.04[b]	0.2 ± 0.06[b]	ANOVA, sqrt (<0.001)
Total_cost *(USD/hectare/month)*	1,115 ± 147[a]	1,768 ± 389[b]	1,854 ± 458[b]	ANOVA, sqrt (<0.001)
Family_labour_cost *(USD/hectare/month)*	38.0 ± 10.6[a]	92.7 ± 17.6[b]	108.4 ± 46.4[b]	ANOVA, sqrt (<0.001)
Hire_labour_cost *(USD/hectare/month)*	11.7 ± 2.5[a]	39.9 ± 13.9[b]	21.4 ± 13.5[ab]	ANOVA, sqrt (0.001)
Net_return *(USD/hectare/month)*	2,682 ± 251	3,310 ± 682	2,856 ± 614	Non-significant
Gross_return *(USD/hectare/month)*	1,568 ± 209	1,542 ± 536	1,002 ± 453	Non-significant

Note: [a,b,c] different letters denote significant difference at the 5% level.

5.4 Discussion

Climate change (Kaveney et al. 2023) and the threats it poses to the profitability of year-round rice production in the VMD (Mills et al. 2023, Mills et al. 2025), is leading farmers and policymakers alike to consider a variety of on-farm and off-farm responses to ensure the of farming family livelihood sustainability. Of the various adaptation measures available, we focused on transition to year-round production of vegetables as alternative crops to rice. This adaptation is a feasible choice for resource-poor farmers, there was existing government support for this measure at the time of writing, and it appears suited to the changing environmental conditions of the VMD. Using typology construction results, we assessed the economic performance of this system as experienced by different clusters of farmers. The research identified three farmer clusters, each with distinct characteristics and implications for supporting farmer adaptation in the VMD.

Our study provides empirical evidence on the applicability of typology in capturing heterogeneity in farmer capacity, as reflected in farmer and their farm characteristics, as well as key production challenges in growing alternative crops in VMD (Bartkowski et al. 2022, Bousbia et al. 2024, Huber et al. 2024). We also offer insights into using typology results in analysing farming and financial performance. However, our findings are limited to generalise insights for the delta or beyond, due to the highly contextual selection of variables and the specific study sample used, which aligns with a review of (Huber et al. 2024).

5.4.1 Characteristics of constructed typologies

Exposure of coastal provinces to salinity and drought impacts

Members in the *Most resilient farmers* cluster were more likely to be located in Long My District, an inland district. Those in the *Moderately resilient farmers* and *Least resilient farmers* clusters were more likely to be located in the two coastal districts of Tran De and Long Phu. Coastal districts such as these face the most severe salinity and freshwater scarcity threats, contributing to reduced rice cultivation in VMD (Mills et al. 2023, Mills et al. 2025). Consequently, members of these two clusters also rated salinity and freshwater challenges as significantly more severe than respondents in the *Most resilient farmers* cluster, and were more likely to report that their main water source, the local canal systems, was insufficient for irrigation. Farmers in coastal provinces of the VMD, and elsewhere in deltaic systems exposed to climate change-related challenges such as salinity and drought, may benefit from increased availability and adoption of water storage infrastructure (both shared and on-farm) and water use efficiency technologies (such as drip irrigation. Greater rates of adoption of drought- and salinity-tolerant crop varieties (including alternatives to rice) may also be required in coastal districts compared with those further inland (Hoang et al. 2019, Duc Tran et al. 2024). Alternative production systems (such as aquaculture) may also be most necessary in coastal districts to provide viable farming income alternatives for farmers (Nguyen et al. 2020b).

Resource access

For members of the *Least resilient farmers* cluster, credit and market accessibility, input availability, and labour shortages were more significant challenges than for members of the other two clusters. Better access to credit would give farmers more scope to invest in technology and inputs (Haryanto et al. 2023), particularly those relevant to novel production systems such as vegetables (e.g. raised crop beds, trellis installation). For vulnerable farmers in particular, credit provision schemes such as microfinance and low-interest loans may be targeted at both farm transformation activities but also participation in employment or small business start-up training programmes, to enable better access to off-farm income streams. Off-farm income may, in turn, provide supplementary funds to reinvest in farming systems and improved productivity (Khoi et al. 2013, Anang & Apedo 2023).

Market access for farmers may be improved through vertical coordination, involving expanded adoption of contract farming, where processors or traders may guarantee purchase in exchange for guaranteed supply, and provide certain crop inputs on credit (Huong et al. 2013a, Le et al. 2025). Horizontal coordination via farming cooperatives may also facilitate improved market access through greater integration of production to value chains, and facilitate sharing of labour resources (Huong et al. 2013a). Strengthened value chains for alternative crops in terms of both vertical and horizontal coordination may assist vulnerable farmers in particular to overcome the challenges of access to farm inputs, suitable markets, and labour.

Farmers in all three clusters identified in this study commonly considered labour shortage an important challenge. Year-round vegetable farming, as carried out by the farmers we surveyed, tends to be more labour-intensive compared to rice, and this system also features lower rates of mechanisation then rice production in the VMD (Huong et al. 2014, Le et al. 2024b). Therefore, it is essential to address labour shortages for farmers via reducing out-migration, especially youth, promoting mechanisation and technological innovations, improving labour skills, and fostering entrepreneurship across the three clusters in the three clusters to support transforming away from rice to alternative crops in study areas and beyond (Le et al. 2024b).

Demographics

In our study, a higher proportion of *Least resilient farmers* and *Moderately resilient farmers* cluster members were of Khmer and Chinese ethnicity, female farmers, and were more likely to have household members with lower education levels. Farmers in the VMD with these demographic characteristics tend to have lower adaptive capacity and are more vulnerable to challenges such as climate change (Le et al. 2024a, Phuong-Dung et al. 2025), as they may be associated with limited access to resources, lower economic status, language barriers (Le et al. 2024a). Their ability to access farm production, or income generation, training or extension services may be hindered by "elite capture", whereby individuals with a higher social status are better able to access public resources (Coe 2016). Thus, in line with (Tran et al. 2022b, Phuong-Dung et al. 2025) our research suggests that efforts to build the adaptive capacity of rural communities in the VMD needs to focus in particular on somewhat disadvantaged farming cohorts, including those with lower levels of education, ethnic minorities and women, but potentially also on the basis of other demographic or social characteristics.

Farming experience

Although we found no difference in general farming experience among the three clusters, experience in producing new types of crops was significantly lower among respondents in the *Least resilient farmers* cluster than in the other two clusters. General farming experience is likely to have been gained mainly through previous rice production. These skills would provide a foundation for cultivating novel crops, but their successful production would require farmers to acquire somewhat different production and marketing skills, to supplement their existing general knowledge (Le et al. 2025). The later transformation to alternative crops of members in the *Least resilient farmers* cluster, compared to other farmers in the other two clusters, might have resulted from their limited capacity to adopt alternatives to conventional crops earlier, as transforming requires farmers to obtain a certain level of asset endowments in the form of physical capital, knowledge and skills (de Janvry & Sadoulet 2019b). In addition to taking up training and extension opportunities in novel crop production and marketing techniques, less resilient farmers such as those included in this research may seek advice from neighbouring farmers or participate in collective organisations to improve their knowledge base (Tran et al. 2020b).

Land area, land-size sufficiency

Members of the *Least resilient farmers* cluster had significantly less land on average than those in the other two clusters, and were most likely to report their land as not large enough to generate sufficient household income for. Land ownership is a key indicator of adaptive capacity, reflecting household wealth and ability to leverage land as collateral to access credit (Khoi et al. 2013, Siders 2019). Smaller land area, therefore, is likely to make it harder for farmers to access the credit they may require to adopt an alternative form of production to rice. Fragmentation of farmland into smaller, less economically viable parcels, also negatively impacts production efficiency, productivity, and per unit costs (Rahman & Rahman 2009, Tran & Vu 2019). Land consolidation is suggested as a promising measure. However, it must be well designed to prevent potential environmental impacts (Tran et al. 2024b). Therefore, we recommend conducting a thorough diagnostic approach to assess the feasibility and potential benefits of land consolidation for the sustainable development of the entire region when designing such projects, in alignment with (Zang et al. 2021).

5.4.2 Economic performance of the three clusters

Crop area

Members of the *Most resilient farmers* cluster cultivated a larger year-round vegetable production area than the other two clusters. This might be a result of better adaptive capacity, along with more favourable production conditions that might enable this cluster to cultivate vegetables year-round at a larger scale compared to the other two clusters (Huong et al. 2013a). Shukla et al. (2019) suggested that farmers with sufficient land and labour resources are more capable of employing “step-up” strategies and adapting to change, where farmers use extensively their resources to cultivate crops in a market-oriented manner rather than by subsistence or traditional approaches focused on self-sufficiency and not driven by profit.

In contrast, members in the *Moderately resilient farmers* and *Least resilient farmers* had access, on average, to smaller production areas, which might have detrimental effects on production efficiency and productivity, and production cost (Rahman & Rahman 2009, Tran & Vu 2019). However, with the extensive crop-growing experience and moderately favourable physical farming conditions of farmers in the *Moderately resilient farmers* cluster, it may be appropriate to focus on crop value and quality, rather than attempting to increase current crop area. For those in the *Least resilient farmers* cluster, the suitability of strategies to scale up vegetable production should be assessed before implementation to optimise their capacity to be profitable (Fan & Rue 2020).

Crop returns

There was no significant difference in gross or net return among the three farmer clusters, which may be due to the high variation in returns within each group stemming from the diversity of crops grown. However, the ability to produce on a somewhat larger scale might enable members in the *Most resilient farmers* to generate higher total annual income from vegetable production than members of the other two clusters. Thus, they might find it easier to rely exclusively on year-round vegetable production for sufficient household income, whereas members of the other two clusters might need to supplement their income. Strategies for supplementary income in the VMD may include occasional farm labour and out-migration for off-farm employment; however however, out-migration is not a sustainable solution due to its potential to exacerbate social inequalities and disadvantage minor ethnic groups (Le et al. 2024a). Therefore, efforts helping farmers sustain with farming through growing alternative crops in the studied areas, especially in Long Phu and Tran De, where members in *Moderately resilient farmers* and *Least resilient farmers* located, might not only improve farmer current incomes but also contribute to general sustainable development. Similarly, farmers are encouraged to

Crop production costs

The total production cost and labour costs for members of the *Moderately resilient farmers* and *Least resilient farmers* clusters were significantly higher than for members of the *Most resilient farmers* cluster. These additional costs may be linked to the less favourable production conditions faced by members of these clusters – for example, as a result of their greater likelihood of being located in a coastal district, or greater difficulty in accessing resources.

Additionally, the lower adaptive capacity of farmers in the *Moderately resilient farmers* and *Least resilient farmers* had which might require more cost during production, especially labour cost. The higher production costs among members of the two clusters could place a burden on them to prepare greater investment each cropping season. Therefore, interventions that help farmers reduce their production costs might be beneficial for those in the two clusters, particularly by lowering labour costs. These interventions could include increasing mechanisation and adopting labour-saving practices such as using less labour-intensive crops, soil cultivation to improve soil fertility.

Other factors related to costs and profitability include

- access higher-value markets (e.g. through contract farming or improved market coordination) to offset higher costs.
- Training and extension in, and adoption of, cost-effective resource saving measures.

- Cooperative farming to share cost burdens.

5.5 Conclusions

As a result of ongoing climate change-related impacts on farming systems in the VMD, farmers are increasingly seeking alternative modes of production to the dominant year-round rice cropping model, which is particularly impacted by salinity and drought in this important "food bowl" of the Mekong Delta. Of the various on-farm adaptations, we focused on year-round production of seasonal vegetable crops as an approach that is already being adopted by some farmers, and which has the support of government. Using a range of socio-economic and farm system variables from a survey of farming households in three districts of the VMD, we constructed a typology of farmers to explore heterogeneity in the sector and facilitate some general conclusions about different cohorts of farmers in this particular system. Three farmer clusters were identified in the data set along a scale of relative resilience. This was used to identify patterns in adaptive capacity, production, economic and marketing challenges, and profitability of vegetable production.

Of the three identified clusters, the *Most Resilient Farmers* cluster had greater adaptive capacity, attributed to their favourable characteristics and less severe production challenges. They operated at a larger scale and incurred lower costs compared to those in the other two clusters. In contrast, members of the *Least Resilient Farmers* cluster had the lowest adaptive capacity and faced the most severe production challenges, particularly salinity. These findings have implications for how different categories of farmers may adopt and maintain a new form of production.

Certain characteristics of each cluster in our research indicated different adaptation pathways should be prioritised in order to tailor adaptation support for each cluster, on the basis of resilience. Less resilient farmers in particular are likely to benefit most from many forms of external top-down assistance, including adoption of cost-effective technologies to improve efficiency; access to suitable, low-risk forms of credit to facilitate farm systems investment; delivery of training and skills development for new modes of production, with a particular focus on ethnic minorities and women farmers; production experience improvement; and small-scale production. More profitable and experienced farmers would likewise benefit from these types of assistance; however their needs should be prioritised below those of the least resilient farmers, with support focused on addressing labour shortages and supporting large-scale production.

However, the research also indicates that there are opportunities for farmers themselves to benefit further from their adoption of year-round vegetable production in the VMD. This may include networking with other farmers in their community (either informally, or formally through collectives) to pool their knowledge and resources for mutual benefit. There may also be considerable opportunity for farmers to gain access to higher-value markets, and to knowledge and inputs, for these forms of produce by participating in formalised farming contracts. Again, the focus of these activities should be on the least resilient and therefore most vulnerable farmers, however more resilient farmers are also likely to benefit from such activities to some degree, even though they were suggested for large-scale production pathways.

Using the VMD as an example, this research illustrates how construction of a typology of farmers can be useful for policymakers, extension agents and researchers seeking to identify needs of distinct cohorts within a farming population, or to identify how farmers themselves, from different cohorts, may approach adaptation in their own way. While there is no single pathway to successful adaptation amongst a farming population, nor is it possible to tailor any forms of advice, support or policy to the needs of each unique farmer's circumstances. Typology provides a middle ground in which great diversity in the farming population can be broken down into more manageable, but also more usable categories for research, extension and support.

The research also suggests an increasing shift away from farming as a profession in the VMD. This is partly as a result of salinity and drought and their negative impacts on farm income, but is also due to other factors such as urban and industrial growth and economic diversification in the VMD. Consequently, rates of participation in off-farm employment or business establishment are increasing amongst farming families in the region (Tran et al. 2021b, Tran et al. 2023). Vocational training to improve the capacity of local people for off-farm work may help, signifying a shift from traditional employment patterns to a modern economy.

A structural shift in the regional economy of this nature may pose increasing concerns for labour availability for cropping in the VMD. However, these off-farm options are viable adaptations that can be expected to increase farming family income and, in many cases, to supplant farming as the family's main income source. Possible adaptation options include mechanisation and aggregation.

Chapter 6. Householder decision-making for dry season crop production

Paul Kristiansen and Michael Coleman

6.1 Introduction

In order for farmers to be willing to diversify their production system and produce commodities other than rice, demand for alternative crops must increase to an extent where alternative forms of production are profitable (Chapter 7). Production costs need to allow for an acceptable profit margin, and there must be a market chain in place to support buying, transport, and sale of the alternative products to reliable domestic and/or international markets.

Many smallholder farmers in the VMD have shown a preference to continue growing rice alone in preference to diversifying to other crops, given the perceived reliability of rice as an income source and their knowledge of its production system and value chain (Ministry of Natural Resources and Environment & al. 2013, World Bank 2016a). Nonetheless, farm gate prices per unit of production for rice appear to be low relative to some crop alternatives. This may be due to a historic focus on producing higher-yielding but relatively low-quality rice, aimed at capturing lucrative export markets (Nguyen et al. 2020a).

Food consumption patterns in Vietnam have been changing to incorporate a more diverse diet which involves less reliance on the rice-based staple. Diet diversification has involved purchasing more non-grain products and processed foods from supermarkets, and enjoying more frequent restaurant-prepared meals (World Bank 2016b). Given this gradual shift in consumer demand, both domestic and export markets for farm produce other than rice are growing, providing ever-increasing opportunities for farmers in the VMD to diversify their production to fulfill viable market requirements. For example, Hoan et al. (2019) suggested that prices available for shrimp through well-established domestic and export markets motivated farmers to shift to a rice-shrimp system where they possessed the skills and resources to do so. However, these researchers also suggested that at the time their research was completed, demand for non-rice crop produce such as vegetables needed to increase further, to allow these to be an economically attractive companion (or alternative) annual or seasonal cropping system to rice.

Below, we present information regarding:

1. Reasons for growing the most common non-rice crops either in the field or on the embankment;
2. Sources of information used to grow these non-rice crops;
3. Sales/marketing pathways for dry season crops; and
4. Advantages and disadvantages of selecting the dry season crop options (field and embankment) grown by the HHS respondents.

The relative profitability of the various dry season vegetable crop options grown by respondents to the HHS is covered in more detail in Chapter 7**Error! Reference source not found.**.

6.2 Methodology

Please refer to Section 2.2 for details. The methodology to collect the HHS data presented in Chapters 2, 4, 5, 6, 7 and 9 was identical.

6.3 Results

Dry season crops offer farmers an alternative to rice where water for irrigation is insufficient for rice production in the dry season, or where salinity may impact their capacity to grow rice successfully in the dry season (Nguyen et al. 2020a). In Hau Giang province, however, rice was still generally considered the best dry season option by respondent farmers, offering a range of advantages at the local level:

- relatively less salinity pressure in this province at the time of writing;
- rice was a reliable staple food crop for the farming household itself, in the event that it cannot be sold profitably;
- rice can be stored for longer under volatile market conditions, in anticipation of future price rises and opportunity to sell the crop – in contrast, many dry season crops tend to be relatively perishable under storage; and
- the costs of growing dry season crops were considered higher than rice, due to the need to prepare raised crop beds, and due to the cost of crop seed and inputs – meaning that dry season rice alternatives may be considered relatively higher risk options.

Similarly in Soc Trang province, farmer discussion with research team members suggested that rice production required a smaller investment of resources to grow and was therefore considered a lower risk option. Rice production was also a long-standing tradition amongst local farmers, making them highly skilled in its production relative to any likely alternatives.

Nonetheless, farmers who were willing to take the risk of growing a non-rice dry season crop considered these options to be relatively profitable and to provide more rapid turnover given their often shorter growing period relative to rice. Dry season crops, however, need to be planted to a sufficient scale to ensure interest from traders or buyers, to warrant investment in their production.

The high cost of preparing raised beds in the field for a dry season non-rice crop, followed by removal of these raised beds for a subsequent rice crop, means that many farmers in the study area were reluctant to produce a rotation of wet season rice and dry season non-rice crops across a calendar year. There was instead a sense that if a commitment was made to non-rice crop production, this would become a year-round alternative to rice brought on by factors such as salinity or production or price advantages of these crops.

6.3.1 Dry season crop decision-making and information

Interviewees were asked why their household started growing their dry season crop options (in the field and/or on the embankment). Table 27 reports the findings for dry season crops that were grown by at least 10 of the households surveyed. While there were some differences in results between these more commonly adopted dry season crop options, across all dry season crops (including those less commonly produced varieties not listed in the table) the reasons for crop selection may generally be summarised as follows:

- Economic: high and/or relatively stable price combined with acceptable to high profitability; relatively easy access to a stable market for the crop; high yield; improved overall farming household income.
- Agronomic: drought/dry season tolerant (low water requirements); relatively disease/pest tolerant; quick rates of growth; adaptability to the soils prevalent in the region; useful for soil conditioning/improvement.
- Management: prior household experience in growing the crop; access to support from neighbours; varieties that were easy to grow and harvest; relatively low input requirements (labour, fertiliser, pesticide, capital); making full use of the land (e.g. rather than adopting a dry season fallow).

Other reasons given for growing particular dry season crops that were not covered in the table below included:

- Selecting a particular crop (beetroot) after attending a CTU production workshop.
- Suitability of the crop to small land areas (leaf mustard).
- Having the potential to produce fruit several times in a single growing season to maximise productivity (string beans).

Table 27. Reasons households chose to start growing particular dry season crops (where at least 10 households were growing each crop)

Crop name (where n ≥ 10)	Why farmers decided to start growing the crop
Watermelon (n = 54)	Easy to cultivate/grow and harvest; high profitability relative to other crop options (including rice); high yield; growing quickly; drought/dry season tolerant, low water requirements; low labour input requirements; prices and yield relatively stable; a traditional family crop; soil improvement.
Cucumber (n = 44)	Performed well in the dry season; can be grown year-round; high profitability (e.g. to cover household costs); grows quickly; easy to sell and consume; efficient use of water; high yield; easy to cultivate/grow and harvest; price for crop tended to be stable; had a lot of experience growing the crop.
Spring onions (n = 40)	Easy to cultivate/grow and harvest; high yield and price received; grows quickly; growing to imitate neighbours; did not have information about other crops; suitable soil on the farm for this crop.
Corn (n = 28)	Required relatively low inputs e.g. fertiliser; easy to sell and consume; preferable to fallow; easy to cultivate/grow; use as a livestock feed; grows quickly; provided a stable and diversified income; could learn how to grow the crop from friends/neighbours; relatively few pests; utilise soil that was not suited to rice production; drought tolerant and low water input requirements.
Chilli (n = 19)	High yield, price/profit compared to rice; providing capacity to use land fully and produce income in addition to rice; support and advice available e.g. from neighbours; easy to cultivate/grow; low labour input requirements; had experience in growing the crop.
Honeydew melon (n = 18)	High profitability; easy to cultivate/grow; grows quickly.
Okra (n = 17)	Easy to cultivate/grow; high profitability (e.g. to cover household costs); low labour and input cost requirements; impacted by relatively few pests; could sell at the farm gate; grows quickly; new varieties were available.
Bitter melon (n = 15)	Suitable soil on the farm for this crop; easy to cultivate/grow and harvest; high yield/profit; had experience in growing the crop; suitable as a rotation to improve the soil; impacted by relatively few diseases; more suitable to the farm than other options.
Squash (n = 11)	Easy to cultivate/grow and harvest; required relatively low labour as well as inputs e.g. fertiliser, pesticide; well adapted to drought; high yield/profitability; grows quickly; relatively few pests; experienced in growing the crop; easy to sell; stable price and market for the crop.
Pumpkin (n = 10)	Easy to sell; grows quickly; easy to cultivate/grow; low labour requirements; suitable soil on the farm for this crop; required less fertiliser, pesticide and capital inputs.

6.3.2 Dry season crop sales

Interviewees were asked to summarise, for one or more dry season crops grown by their farming household (both field- and embankment-grown): who purchased their crop's produce and what proportion was purchased by different entities; who decided on the price received for the produce; and to rate the acceptability price received in the most recent year each dry season crop being considered in the survey was grown.

Because some interviewees gave information for two crops, frequencies are generally reported in the following tables rather than percentages. Table 28 summarises the various buyers of crop produce amongst surveyed households, and the mean proportion of the crop purchased by each category of buyer across all interviewee households producing one or more dry season crops. Local wholesalers are the most significant avenue of crop sales amongst the farming households in this study, both in terms of number of instances this category of buyer was used, and the proportion of the crop sold through this avenue. Middlemen and local wet market retailers were also important avenues of sale for crop produce, while the survey suggested no direct pathway of sale for crop produce from farmers to processing companies.

Table 28. Buyers of dry season crop produce from surveyed households, and average proportion of produce purchased by different categories of buyer

Buyer of crop produce	Mean % of produce purchased	Standard deviation % of produce purchased	n
Local wholesalers	55.7	49.3	187
Middlemen	28.0	44.6	106
Retailers of local wet markets	15.0	35.1	54
Sale from the farm gate	1.3	11.2	4
Representatives of processing companies	–	–	0

Amongst the survey response group, decision-making power regarding the price obtained for crop produce appeared to be relatively in favour of buyers. Price being determined on the basis of a negotiation between sellers and buyers was the most common approach, while it was nearly as common for buyers alone to set the price they were willing to pay for produce. It was relatively uncommon for sellers themselves to determine the price they received (Table 29).

Table 29. Who decided on the price of crop produce from surveyed households

Who decided on crop produce price	n
Negotiation between sellers and buyers	149
Buyer	131
Seller/grower	42

The majority of interviewees rated the acceptability of the price received for their dry season crop/s, in the last season in which the crop was grown, as 'medium'. This may indicate overall ambivalence about price. It is perhaps notable, though, that the interviewee group were more likely to give the price received a rating of 'high' than 'low', suggesting to some extent that dry season crop prices were satisfactory to farming households (Table 30).

Table 30. Rating of the price received in the most recent year that dry season crops addressed in the survey were grown

Rating of price received for crop	n
High	72
Medium	209
Low	37

The interviewees were asked to consider a number of ways in which they might seek to increase the price their household received for its dry season crop options (Table 31). The most commonly nominated option was to find new buyers, while growing the crop in a different period of time (within the off-season) was the next most common option considered. The fact that none of the interviewees would consider selling to an export market suggested weak to non-existent direct linkage, or market chains, between farmers and export markets for dry season crops in the study area. Enumerator discussion with respondents also suggested that this may also be due to the quantities of chemicals used on crops, which served to restrict export opportunities where strict chemical use criteria were imposed as part of broader crop quality assurance schemes.

Table 31. Options available to households to increase the price obtained for dry season crops

How interviewees would seek to increase their crop's sale price	n
Find new buyers	107
Shift to grow the crop in the off-season	70
Sell in Ho Chi Minh City	11
Sell to an export market	-
Sell through other traditional markets	5

6.3.3 Dry season crop production advantages and disadvantages

For the dry season crop/s produced (both field- and embankment-grown), interviewees were asked to list their advantages and disadvantages from the production perspective. Many interviewees noted more than one advantage and/or disadvantage. Responses were on the whole relatively brief, and were coded into a number of categories which were further grouped according to larger categories of agronomy, climate, farm management and economics. The resulting information has been summarised in Table 32 (advantages) and Table 33 (disadvantages). Interviewees most commonly produced dry season crops that were considered easy to grow and manage, to grow quickly, to be relatively efficient in their use of labour, water, fertiliser and pesticide, and to be prone to relatively less incidence of pest and disease (Table 32). Only a few respondents noted that dry season crops offered tolerance to drought, and none mentioned their adaptability to salinity. This information may be considered alongside Table 27 for a more complete picture of the advantages of growing the more common crop varieties, with some overlap in both sets of information.

Table 32. Summary of the production advantages of dry season cropping, sub-categorised into farm management, economic, agronomic and climatic advantages, and with relevant crop/s listed

Advantages of crop/s for production (number of times advantage listed)	Relevant crop/s
Farm management factors	
Easy to grow (n = 70)	Beetroot, bitter melon, bulrush, cabbage, celery, chilli, corn, cucumber, daikon, gourd, lotus, mung bean, mushroom, okra, honeydew melon, pumpkin, rockmelon, spring onions, squash, tomato, watermelon, winged bean
Easy to manage (n = 66)	Bitter melon, chilli, corn, cucumber, eggplant, garlic chives, lotus, luffa, okra, honeydew melon, pineapple, spring onions, watermelon, yam bean, yardlong bean
Low water requirements (n = 30)	Bitter melon, cabbage, chilli, corn, cucumber, mung bean, Asian greens, okra, spring onions, squash, watermelon
Less fertiliser needed (n = 19)	Chilli, corn, cucumber, lettuce, luffa, mushroom, okra, spring onions, squash, string bean, tomato, winged bean
Less pesticides needed (n = 15)	Chilli, corn, cucumber, lettuce, luffa, okra, spring onions, squash, tomato, watermelon, winged bean
Easy to harvest (n = 10)	Bitter melon, corn, cucumber, daikon, spring onions, squash, watermelon
Had previous experience growing crop (n = 5)	Bitter melon, chilli, cucumber, watermelon, winged bean
Several harvesting periods (n = 3)	Chilli, spring onions, string bean
Could use as cattle feed (n = 1)	Corn
Economic factors	
Low labour requirements (n = 39)	Bitter melon, chilli, corn, cucumber, daikon, gourd, lettuce, Asian greens, okra, pumpkin, spring onions, squash, string bean, tomato, watermelon, winged bean, yardlong bean
Profitable/good price received (n = 9)	Chilli, cucumber, okra, honeydew melon, squash, watermelon
Easy to sell (n = 8)	Chilli, corn, cucumber, winged bean
Inexpensive to produce (n = 7)	Chilli, cucumber, Asian greens, pineapple, squash, string bean
Stable income/price (n = 6)	Cucumber, spring onions, squash, water spinach, winged bean
Cost-effective (n = 2)	Corn, pumpkin
Agronomic factors	
Grows quickly (n = 53)	Beetroot, bitter melon, Chinese cabbage, corn, cucumber, lettuce, luffa, Asian greens, okra, honeydew melon, spring onions, string bean, watermelon, yam bean, yardlong bean
Relatively few pests/diseases (n = 17)	Cabbage, corn, lettuce, Asian greens, finger root (ngải bún), spring onions, squash, water spinach, winged bean, yardlong bean
High yield (n = 7)	Cucumber, Asian greens, squash, winged bean

Advantages of crop/s for production (number of times advantage listed)	Relevant crop/s
Grows year-round (n = 1)	Corn
Climatic factors	
Dry season/drought tolerant (n = 2)	Watermelon
Performs well in rainy season (n = 2)	Cucumber
Suitable weather (n = 2)	Celery, okra
Dry season/drought tolerant (n = 1)	Asian greens

When considering the production *disadvantages* of dry season crops grown by surveyed households, interviewees were much more likely to focus on agronomic and climatic disadvantages (Table 33). Unsuitable weather was a particular focus and the response was presumed to be largely addressing unsuitability to wet conditions – though in many cases this was not specified by the interviewees. However, waterlogging of crops was often a particular concern. Although some interviewees had noted the relative tolerance of pests and disease of dry season crops as an advantage (Table 32), many more considered that their proneness to pests and disease was an important disadvantage (Table 33). High input prices were also a common concern, though these were likely to be a concern for rice production as well.

Table 33. Summary of the production disadvantages of dry season cropping, sub-categorised into farm management, economic, agronomic and climatic disadvantages, and with relevant crop/s listed

Disadvantages of crop/s for production (number of times advantage listed)	Relevant crop/s
Farm management factors	
Difficult to harvest (n = 6)	Cucumber, lotus, okra, spring onions
High input requirements (n = 6)	Bitter melon, cucumber, spring onions
Insufficient water (n = 5)	Celery, cucumber, mushroom, Asian greens
Difficult to manage (n = 2)	Pumpkin, spring onions
Hard to manage (n = 1)	String bean
Labour intensive for older farmer (n = 1)	Corn
Economic factors	
High input prices (n = 21)	Bitter melon, chilli, corn, cucumber, okra, honeydew melon, spring onions, watermelon, winged bean
High labour requirements (n = 7)	Cabbage, corn, cucumber, spring onions
High fertiliser prices (n = 6)	Honeydew melon, watermelon
Hard to find suitable market (n = 1)	Watermelon
High production costs (n = 1)	Cucumber
Not profitable (n = 1)	Chilli
Unstable market (n = 1)	Okra
Agronomic factors	
Pest/disease prone (n = 59)	Bitter melon, chilli, corn, cucumber, daikon, gourd, Asian greens, finger root (ngải bún), okra, pear-shaped melon, pumpkin, rockmelon, shallot, spring onions, squash, string bean, watermelon, winged bean
Difficult to grow (n = 1)	String bean
Soil unsuitable (n = 1)	Corn
Climatic factors	

Disadvantages of crop/s for production (number of times advantage listed)	Relevant crop/s
Intolerant of prevailing weather (n = 44)	Chilli, cucumber, lettuce, luffa, okra, pear-shaped melon, pumpkin, spring onions, string bean, watermelon
Intolerant of heavy rainfall/waterlogging (n = 43)	Bitter melon, chilli, cucumber, daikon, lettuce, Asian greens, honeydew melon, pumpkin, spring onions, watermelon
Intolerant of salinity (n = 3)	Corn, cucumber, watermelon

Given the potential advantages and disadvantages of the dry season crops as summarised in the previous two tables, the interviewees were asked whether or not their households would grow the crop/s discussed again in the future.

Over 91% of the interviewees noted that they would grow previously produced dry season crops again in the future. Reasons given for this decision have been summarised in Table 34. These were most likely to be associated with: economic factors including crop profitability and affordable labour requirements; management factors including ease of growth and prior household experience growing/managing the crop; and agronomic factors including crop growth rate. Climatic factors were relatively rarely raised as issues influencing the decision to produce a dry crop again (Table 30).

Table 34. Summary of the reasons for being willing to grow particular dry season crops again, sub-categorised in the areas of farm management, economics, agronomy and climate, and with relevant crop/s listed

Reasons for being willing to grow certain dry season crop/s again	Relevant crop/s
Farm management	
Easy to grow/manage (n = 59)	Bitter melon, celery, corn, cucumber, daikon, eggplant, lettuce, mushroom, mung bean, Asian greens, okra, pumpkin, spring onions, squash, string bean, watermelon, winged bean, yam bean
Have experience growing the crop (n = 43)	Bitter melon, cabbage, celery, chilli, corn, cucumber, daikon, gourd, Asian greens, finger root (ngải bún), okra, spring onions, squash, tomato, watermelon, winged bean
Less fertiliser needed (n = 6)	Asian greens, spring onions, tomato, winged bean, yam bean
Low water requirements (n = 6)	Corn, Asian greens, pumpkin, squash
Use small land areas fully (n = 4)	Corn, cucumber, spring onions
Less pesticides needed (n = 3)	Asian greens, spring onions, tomato
Use as livestock feed (n = 2)	Corn
Aiming to improve farm productivity/scale-up (n = 1)	Chinese cabbage
Easy to harvest (n = 1)	Spring onions
Easy to process for sale (n = 1)	Cabbage
Family tradition (n = 1)	Watermelon
Lasts well in storage (n = 1)	Cabbage
Economics	
Profitable/high price received (n = 117)	Beetroot, bitter melon, cabbage, celery, chilli, corn, cucumber, daikon, lettuce, luffa, Asian greens, okra, honeydew melon, pineapple, pumpkin, rockmelon, spring onions, squash, string bean, tomato, watermelon, winged bean, yardlong bean
Low labour requirements/can use family labour only (n = 18)	Bitter melon, celery, corn, luffa, pumpkin, spring onions, squash, string bean, tomato, watermelon, winged bean
Stable income/market for crop (n = 15)	Chilli, corn, cucumber, lotus, shallot, spring onions, string bean, water spinach, watermelon
Easy to sell (n = 7)	Corn, cucumber, mung bean, Asian greens, spring onions
Inexpensive to produce (n = 4)	Corn, cucumber, daikon, mung bean
Allows household costs to be covered (n = 3)	Cucumber, okra, honeydew melon
Easy to consume (n = 3)	Cucumber, honeydew melon, watermelon
Agronomy	
Grows quickly (n = 55)	Bitter melon, chilli, corn, cucumber, garlic chives, lettuce, luffa, mung bean, okra, honeydew melon, pumpkin, spring onions, squash, tomato, watermelon, winged bean, yardlong bean
Improve soil (n = 3)	Bitter melon, watermelon, yardlong bean
Grows year-round (n = 2)	Cucumber, yardlong bean
High yield (n = 2)	Spring onions, winged bean
Suited to soil conditions (n = 2)	Bitter melon, pineapple
Climate	
Drought tolerance (n = 2)	Bitter melon, winged bean
Offers a dry season alternative (n = 2)	Watermelon
Suitable weather/region for the crop (n = 2)	Lotus, squash
Adapted to salinity (n = 1)	Corn

Only just over 8% of responses received indicated that the crop in question would not be grown again. Reasons provided included:

- Not having enough experience to manage the crop to a desired standard.
- No longer being physically able to manage the crop (e.g. unhealthy, too old).
- Having access to insufficient dry season farm labour to manage the crop.
- Finding the crop to be unprofitable.
- Finding prices received for the produce to be unstable or unreliable.
- Preferring to grow rice, or other dry season crop options.
- Finding their land and/or local climate to be unsuitable to the crop.

6.4 Discussion and conclusions

Vegetable production, either in the dry season or year-round, can offer a sustainable adaptation to declining rice yields and the impacts of climate change in the VMD. Key advantages of this form of cropping depend on the crops grown, but farmers were generally driven by higher prices received for non-rice crops and their drought and salinity tolerance. The research shows that many farmers remain comfortable with rice production given its farming system advantages, including lower production costs, longer storage life, familiarity with production practices, and a well-established and familiar value chain.

6.4.1 Market engagement

More than half of all households participating in the HHS had no marketing arrangements in place at the time of writing. Given the low level of marketing engagement by respondent farmers, there is a significant opportunity to link a greater proportion of farmers to external marketing support to improve their capacity for market engagement. Market awareness raising may help farmers to obtain higher prices. Expanding market access and processing capacity of crops that are new to the VMD may be achieved by aligning overarching programmes (e.g. OCOP) with local government development initiatives (e.g. Rural Youth Entrepreneurship Project).

Those farming households who had been willing to take the step of producing vegetables had generally found it a more profitable undertaking than rice. The large majority of the farmers surveyed for this project were willing to grow the same vegetable crops again, reinforcing that they considered these crops to be sufficiently profitable and feasible to grow.

The costs of shifting between production systems for rice and vegetables in a calendar year (especially with regards to raised crop bed formation for vegetable crops, followed by field levelling for production of rice) means that transforming to year-round vegetable production in place of rice, is likely to be a better choice than a mixed system of wet season rice and dry season vegetables. Farmers obtaining diminishing yields from rice production due to climatic conditions, are more likely (and should continue to be encouraged) to change to a year-round alternative to rice production, rather than dry season only.

6.4.2 Marketing pathways

Avenues of sale for alternative crops primarily involved wholesalers and other middlemen, though some sold their crops direct to a retailer. However, generally the buyers seem to have more decision-making power in determination of sale price. Increased use of contract farming, and potentially collective negotiation of price by farmers, may strengthen farmer power in price negotiations and deliver increased prices as well as price stability.

Great utilisation of collective or cooperative production may address issues related to farm scale and the capacity of and resources available to individual smallholder farmers to adopt new forms of cropping (Huong et al. 2013b, Le et al. 2024a). However, some of the drawbacks of collective farm approaches need to be addressed for farmers to have greater confidence in the personal benefits of such an approach. These include inequitable benefit distribution, excessive time spent on perceived irrelevant activities, and limited capacity of cooperative management need to be addressed in order for more farmers to perceive that the benefits of cooperative production of alternative crops may outweigh the costs (Nguyen et al. 2023).

None of the farmers participating in the HHS had a contract in place with a buyer for their crop at the time of writing. There is a significant opportunity to improve rates of uptake of contract farming amongst farmers in the VMD. The benefits of doing so would include greater certainty and stability of price received and availability of a market; and access to support from the buyer such as guaranteed and timely access to essential crop inputs, and production advice. Contracts between buyers and farming groups/co-operatives, rather than single farmers, may allow farmers as a group to bring more pressure to bear in price and contract condition negotiations, and achieve better outcomes.

A drawback of contract farming as perceived by HHS participants was that contracts had onerous conditions with regards to quality of the produce. Buyers may address this by providing their contracted farmers with appropriate production, storage and transport skills development opportunities to maximise the chance that produce meets contracted quality standards. Buyers and farmers alike would benefit from resulting improvements in the quality of produce delivered to buyers. Such skills development will be especially relevant to recent adopters of novel non-rice crops, for whom these skills will be less familiar.

There is potential opportunity to develop export or high value-oriented value chains for some of the vegetable crops that are being grown in the VMD in place of rice. Export market linkages appeared to be weak at least amongst our survey response group, and high-value market access was not specified. Further work may be required to determine the extent of export market or high-value market value chains already in place, however see Chapter 9 and Chapter 10 for discussion of these market opportunities. Such markets might open up new opportunities to smallholder farmers including higher prices, niche market segments (such as organic or high quality certified produce) and increased value-adding through processing and sale of manufactured goods, including business start-up opportunities in the areas of marketing and processing.

Chapter 7. Farmer perspectives of alternative crop profitability

Mao Huynh Nhu, Paul Kristiansen, Michael Coleman and Le Thanh Sang

7.1 Introduction

Globally, agriculture is shifting towards more sustainable means of production in response to unfavourable climate changed-related conditions. Adaptation strategies range from small adjustments to existing farming systems (e.g. planting dates, alternative input choices, crop diversification); through to extensive transformations entailing substantial and fundamental changes in land use and farming systems or non-agricultural forms of income generation such as alternative crop production, migration, and non-agricultural business activities (Howden et al. 2007, Aryal et al. 2020). In Asia, these strategies are expected to enhance resilience and sustain the viability of farming and rural communities, particularly in delta areas where the dominant form of agricultural production, extensive year round rice cropping, is sensitive to climate-related effects such as saline intrusion and drought (Kabir et al. 2017, Schneider & Asch 2020).

Rice production in Vietnamese Mekong River Delta (VMD) is crucial for global food security, providing a livelihood for nearly 20 million people (Le et al. 2024a), comprising over half of Vietnam's total rice production land area and output (Tho & Umetsu 2022), and contributing over 90% of Vietnamese rice exports (The Anh et al. 2020).

However, the ongoing sustainability of the dominant year-round 'triple-rice' (three annual rice crops) production model is threatened by freshwater scarcity (Nguyen et al. 2020a), heavy reliance on agro-chemicals (World Bank 2016b), greenhouse gas emissions (Tran et al. 2018, Tho & Umetsu 2022, Ackerl et al. 2023), and declining yields and diminishing profit margins as a result of increasing frequency, severity and area of salinity (Kaveney et al. 2023, van Aalst et al. 2023a) and drought (Lavane et al. 2023, van Aalst et al. 2023a).

Modifications may be introduced into existing triple-rice production systems to sustain crop yield and/or quality. These include optimising or increasing input use, modified planting methods, improved variety selection (Nguyen 2017, Devkota et al. 2019, Tho & Umetsu 2022) and increased labour usage (Tran et al. 2020a). However, increased use of inputs such as water, fertilisers and crop protection chemicals can have negative side-effects including environmental degradation and harmful human health impacts (Duc Tran et al. 2023), reduced rice crop profitability due to increasing costs. Increasing labour inputs is also likely to reduce the profitability of rice cropping. Reduced profitability has been identified as a key driver of farmers exiting from rice production in the VMD (Mills et al. 2023, Mills et al. 2025).

An increasingly common on-farm adaptation in the VMD is to include non-rice alternatives in a more diversified, and sustainable, production system (Lin 2011, Le et al. 2024a). The Government of Vietnam has advocated increased production of non-rice farm outputs, such as vegetables (either grown only in the dry season in rotation with rice, or as a year-round alternative to rice), various fruit crops (implemented as a long-term alternative to rice) and aquaculture (e.g. shrimp or numerous species of fish, as a rotation or a year-round non-cropping alternative) (GoV 2021, MARD 2023). On the bunds (embankments surrounding rice fields), further diversification of farm production may involve production of non-rice crops including fruit, vegetables or mushrooms (Borelli et al. 2017, Horgan et al. 2023).

Fruit production in former rice fields commits farmers to a more permanent change in their production system (Le et al. 2024b). Aquaculture or annual vegetable cropping makes it possible to revert to triple-rice if desired (Dey & Prein 2005, Le et al. 2024b), though conversion to aquaculture may be limited by rules governing the use of rice farmland (Dam et al. 2021). Conversion to annual non-rice cropping, such as vegetables, is therefore the most feasible option, requiring less financial investment but also less time and redevelopment of skills and knowledge (Huong et al. 2013b). Establishing a permanent rather than seasonal vegetable production system also obviates the need to carry out raised vegetable bed formation in a flood-based system every dry season, considerably reducing land management costs (Huong et al. 2013b, Huong et al. 2014). In the remainder of this paper, 'alternative crops' refers to annual vegetable crop varieties that may be produced by farmers in the VMD as an alternative to growing rice in the field, or to supplement farm income when grown on the bunds.

Profitability is a key consideration for farmers in choosing to produce alternative crops instead of rice, in a rice-dominant system such as the VMD (Nguyen et al. 2021). Several studies, in Vietnam and elsewhere, have found vegetable crops to be more profitable than rice (Jansen et al. 1996, Huong et al. 2013b, Huong et al. 2014, Kabir et al. 2017, Nguyen 2017, Pedroso et al. 2017, Jamal et al. 2022). However, this can vary considerably depending on selection of vegetable variety, and prevailing market conditions (Huong et al. 2013b).

7.1.1 Factors affecting farm profitability

Factors affecting farm profitability may include socio-economic characteristics of farmers; as well as farm system characteristics including farm management and biophysical factors (Tey & Brindal 2015).

Two **farmer characteristics** have been used as proxy measures of farmer production capacity and its impacts on farm profitability. **Farmer education level** (or the education level of other family members), and **farming experience** have been found to positively affect household farm business financial performance, given their relationship to improved knowledge of production systems and efficient use of inputs (Rahman 2003, Asfaw & Admassie 2004, Ugwumba et al. 2010, Masuku & Xaba 2013, Ahearn et al. 2018).

Several **farm system characteristics** may impact the profitability of cropping enterprises. **Geographic location** impacts individual farm performance due to landscape usage (e.g. cropping pattern) and environmental and weather variations (Mishra et al. 2009, Poon & Weersink 2011). **Farm size** may impact production efficiency due to economies of scale (Mishra et al. 2009, Masuku & Xaba 2013). **Crop growth duration** has been shown to influence farm profitability. Shorter duration crops may require greater labour inputs per unit of output due to the need to complete several tasks in a shorter time frame; while longer crop durations may be more profitable, allowing for more efficient input allocation and potentially improved productivity (Huong et al. 2013b). Use of **farm inputs,** including seed, fertiliser, and labour, have shown mixed results in previous research in terms of the relationship between quantity used, and crop profitability (Huong et al. 2013b, Blanc et al. 2016, Ahearn et al. 2018, Devkota & Yigezu 2020). Though sufficient **access to inputs** is a key driver of successful transformation into different forms of production for small-scale farmers (De Janvry & Sadoulet 2019a), facilitating timely application or usage to maximise crop yield and profitability (Rahman 2003). Finally, reliable **access to information** can have a positive effect on the profitability of farmers by enhancing efficiency through use of informed best practice (Masuku & Xaba 2013), particularly with respect to crop agronomy and management (Nikam et al. 2022). However, the impact of information access on farm profitability can vary depending on information source, quality, and method of delivery (Truong et al. 2015, Nikam et al. 2022).

7.1.2 Research questions

In this study, we analysed the profitability of alternative crops and factors affecting the profitability for two types of year-round production that offer pathways for farm production transformation: producing vegetable crops in farm fields; and producing vegetable crops on the bunds.

While previous research provides some specific comparative examples of the relative profitability of particular vegetable crops vs rice, limited research was identified where the profitability of a wide range of rice-alternative vegetable crops was evaluated (Huong et al. 2013b). We therefore sought to address the following research questions, via a household survey of smallholder farmers in three districts of the VMD:

1. Which alternative crops are farmers likely to grow in the VMD, and how profitable are the various options?
2. What factors may influence the profitability of alternative crops?

7.2 Methodology

7.2.1 Survey design

A household survey instrument to collect data on the factors affecting the profitability of crop alternatives to rice was designed from October 2021 to February 2022 with reference to the literature and consultation with farmers, other experts, and colleagues conducting research on alternative cropping in the VMD. Several iterations of survey design were completed. Human research ethics approval was provided by the Human Research Ethics Committee of the lead author's institution (HE22-004).

Profitability-related data collection was based on: (a) what would provide a relatively accurate indication of the profitability of alternative crops on each householder's farm; and (b) what information farmers might easily provide in the allocated time. Currency-related data were collected in Vietnamese Dong (VND). Survey data were collected using KoboToolbox (Kobo 2024), facilitating tablet-based data collection and online storage to reduce the risk of data loss. Five enumerators, all students of Can Tho University, were provided training in the data collection approach.

7.2.2 Survey design and data collection

Please refer to Section 2.2 for details. The methodology to collect the HHS data presented in Chapters 2, 4, 5, 6, 7 and 9 was identical.

7.2.3 Data analyses

Data cleaning was carried out to remove outliers to legitimise the data set used for the subsequent analyses, using frequencies and boxplots.

Profitability of alternative crops

The total cost of crops consists of both total fixed costs and total variable costs (Suwanmaneepong et al. 2020). However, fixed costs were not quantified in this study because they are negligible or difficult to measure (Branca et al. 2018). Therefore, total production cost used in this study comprised the sum of all variable costs: land preparation; crop inputs such as seed, fertilisers, irrigation and crop protection; farm labour (including both hired and family labour); and transportation to market. Total crop revenue was calculated by multiplying total crop yield by sale price.

Measures of financial performance used in previous research include gross return, net return, and revenue/cost ratio (R/C ratio) (e.g. Poon & Weersink 2011, Masuku & Xaba 2013, Tey & Brindal 2015). These studies relied on a single index to measure profitability, each providing somewhat differing interpretations of farm profitability (Moran 2009, Ahearn et al. 2018). In this study, we utilised all three of these indices alongside one another to more comprehensively assess the profitability of various alternative crops (Tey & Brindal 2015):

- Gross Return (or gross margin), calculated by subtracting total revenue from total production cost, including family labour costs (Ugwumba et al. 2010, Huong et al. 2013b, Masuku & Xaba 2013, Blanc et al. 2016).
- Net Return (or net income), calculated by subtracting total revenue from total production cost, excluding family labour costs (Poon & Weersink 2011, Gathala et al. 2015).
- R/C Ratio, calculated by dividing total revenue by total production cost, including family labour costs. R/C > 1 equates to a profitable crop; R/C = 0 equates to a break-even crop; and R/C < 1 equates to a loss-making crop (Arifin et al. 2019).

All indices were calculated in VND and converted to United States dollars (USD) at an exchange rate of 1:25,000 (USD/VND). To facilitate comparison between different crops and farms, profitability indicators are presented as USD/ha/month. Variables used are summarised in Table 35.

Table 35. Variables used to evaluate crop profitability.

Variable	Units
Crop name[1]	-
Growing duration[1,2]	Months
Production area[1]	Hectares
Crop revenue	
Total yield	Kilograms
Sale price	VND/kilogram
Total revenue (total yield x sale price)[1,2]	VND
Crop costs	
Land preparation (e.g. bed formation, cultivation)	VND
Seed (quantity used x unit prices)	VND
Fertiliser (quantity used x unit prices)	VND
Protection products (pesticide/insecticide/herbicide)	VND
Irrigation (fuel cost)	VND
Family labour cost (daily rate x total number of days spent of family labour)	VND
Hired labour cost (daily rate x total number of days spent of hired labour)	VND
Transportation (fees paid to transport agent and fuel for self-transportation)	VND
Total costs (sum of the above costs)[1,2]	VND
Crop profitability indicators	
Gross Return ((Total revenue - Total costs)/growing duration/Production area)[1,2]	USD/ha/month
Net Return (Gross Return + (Family labour cost/growing duration/Production area))[1,2]	USD/ha/month
R/C Ratio (Total revenues/Total costs)[1,2]	-

[1] Denotes variables used in crop profitability data analyses and presentation.
[2] Denotes variables calculated from raw data.

7.2.4 Experimental models to estimate factors affecting profitability

We employed multiple regression analysis to estimate profitability models using the Ordinary Least Squares estimation method. Assumptions of multicollinearity and heteroskedasticity and normality were tested by using correlation coefficients and diagnostic plots (Wooldridge 2013). The profitability models of factors affecting profitability of crops were developed with the three dependent variables described above: Net Return, Gross Return, and R/C Ratio. Eleven independent variables were included in each subset of data, which were comprised respectively of Field crop responses and Bund crop responses. Observations with large standardised residuals (> 1.3) were removed for each regression model. The dependent and independent variables used for regression are listed in Table 36.

Table 36. Dependent and independent variables used in the multiple linear regression of factors affecting crop profitability, and expected sign of coefficient based on previous research.

Variable	**Unit of measurement**	**Sign**
Profitability indicators (dependent variables)		
Gross Return	USD/ha/month	N/A
Net Return	USD/ha/month	N/A
R/C Ratio	-	N/A
Factors influencing alternative crop profitability (independent variables)		
Farmer characteristics		
Education (highest education level of household member) – 2 categories	Senior high school and above; and below senior high school (reference group)	+
Growing experience (numbers of crops grown) – numeric	Number of seasons crop produced	+
Farming system characteristics		
District – 3 categories	Long My, Tran De, and Long Phu (reference group)	+/-
Crop area – numeric	Hectares	+/-
Information source for crop production – 4 categories	Family and neighbours, private companies, public media, government agencies (reference group)	+/-
Crop duration – numeric	Months	+/-
Fertiliser (applied in a season) – numeric	Kilograms/hectare	+/-
Seed (applied in a crop season) – numeric	Kilograms/hectare	+/-
Family labour (used in a crop season) – numeric	Days/hectare	+/-
Hired labour (used in a crop season) – numeric	Days/hectare	+/-
Input access challenge –7-point Likert scale	From 1 = no challenge to 7 = extremely challenging	-

7.3 Results

The final dataset, with 45 outliers removed as a result of data cleaning, comprised 273 respondents from three districts within two provinces of the VMD: Hau Giang (Long My district, 84 responses); and Soc Trang (Long Phu district, 88 responses; Tran De district, 101 responses) (Figure 14). This data set was split into two subsets based on crop production system: field (171 observations) and bund (112 observations).

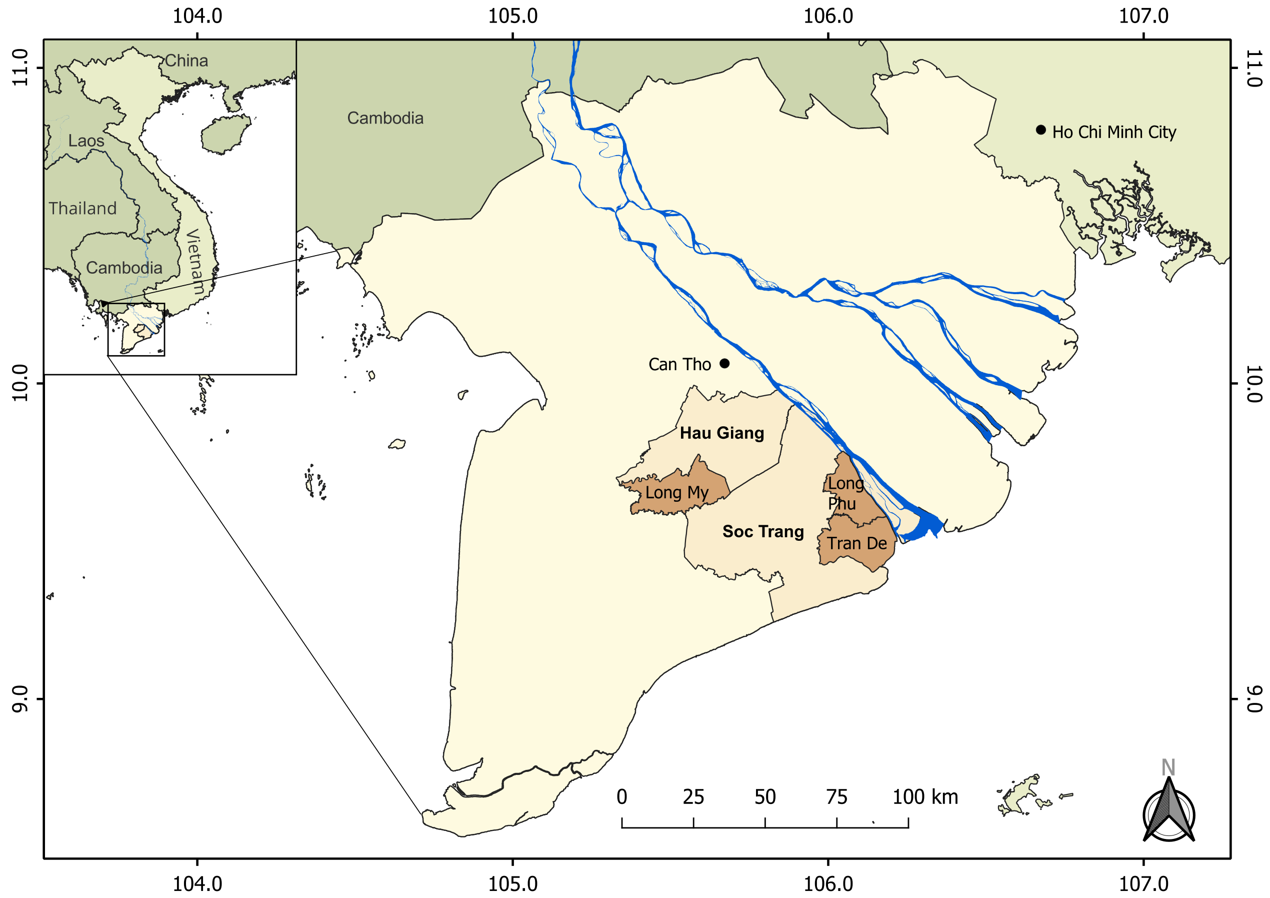

Figure 14. Interviewee household locations in the study area, Long My district (Hau Giang province) and Long Phu and Tran De districts (Soc Trang province).

7.3.1 Profitability of alternative crop options

Table 37 presents summary data for field crops grown by the respondents, while Table 38 presents summary bund crop data. In order to assess land area dedicated to broad categories of crops (Table 39), the individual crops were categorised into functional groups based on growth habit, plant part consumed and crop management system.

The three most frequently grown field crops (Table 37) were in the cucurbit group (Table 39), namely watermelon, cucumber and honeydew melon. Watermelon and honeydew melon were grown on relatively large areas, incurred the lowest family labour costs for respondents, and were amongst the more profitable field crops (Table 37). However, of all field crops grown the most profitable were leafy vegetables – water spinach, celery, and pickled greens. Water spinach featured a relatively short growing duration, while celery and pickled greens had relatively long growing durations. The least profitable field crops were in the cucurbit group – squash, rockmelon and luffa. Winged bean, mustard greens and lettuce incurred the highest family labour costs (Table 37).

The most commonly grown bund crops included spring onions, corn and cucumber (Table 38). Daikon was the most profitable bund crop produced amongst the respondents. Although watermelon was one of the more profitable field crops and the most commonly grown, of the bund crops grown it was the least profitable. A 95% confidence interval (results not shown) found that Gross Return and Net Return were considerably higher for bund crops compared to the field crops identified in the survey, at a 5% significance level (Table 38). Cucumber, Asian greens and yardlong bean were the most family labour-intensive of the bund crops grown.

Cucurbits comprised over 80% of the total land area of field crops grown by the survey response group (just over 50 hectares of the approximately 61 hectares of field crops grown by the response group) and the largest average area of production per respondent (Table 39), but only approximately 30% of the bund crop types grown (just over 4 hectares of a total of nearly 13 hectares of bund crops grown by the response group).

Table 37. Profitability of alternative crops grown in the field. Unless stated, unit is USD/ha/month.

Crop names	**Field crop *(n = 161)***	**Growing duration (months)**	**Average area (hectare)**	**Total area (hectare)**	**Revenue**	**Costs**	**Family labour cost**	**Gross Return**	**Net Return**	**R/C Ratio**
Squash	5	2.2	0.3	1.52	1,311	1,187	360	124	484	1.09
Rockmelon	2	2	0.5	1	1,656	1,436	65	220	284	1.14
Luffa	2	2	0.12	0.25	1,711	1,457	920	254	1,174	1.19
Mung bean	1	2	0.1	0.1	1,040	756	650	284	934	1.38
Lotus	2	2	0.35	0.7	775	418	331	357	688	1.68
Pumpkin	6	2.3	0.3	1.82	1,094	732	281	362	644	1.39
Eggplant	1	2	0.1	0.1	3,072	2,688	744	384	1,128	1.14
String bean	2	2	0.2	0.39	2,123	1,722	514	401	915	1.4
Corn	14	2.4	0.2	2.82	1,392	614	164	778	942	2.58
Spring onions	3	2	0.2	0.61	3,416	2,621	237	795	1,033	1.3
Gourd	2	2	0.17	0.35	3,130	2,320	725	810	1,535	1.29
Lettuce	1	1	0.05	0.05	2,160	1,348	1,190	812	2,002	1.6
Bitter melon	6	1.8	0.21	1.26	2,789	1,964	508	826	1,333	1.27
Okra	11	2.6	0.26	2.81	1,902	700	255	1,202	1,457	2.9
Cucumber	25	1.6	0.23	5.87	4,107	2,901	858	1,206	2,065	1.51
Chili	7	3.3	0.25	1.77	3,104	1,896	206	1,207	1,413	1.92
Mustard greens	1	1	0.07	0.07	3,412	2,175	1,371	1,236	2,608	1.57
Winged bean	5	2.2	0.15	0.75	4,192	2,556	1,483	1,636	3,118	1.79
Watermelon	45	2.2	0.65	29.34	2,807	1,113	82	1,694	1,776	2.67
Honeydew melon	15	2.4	0.59	8.82	2,635	754	61	1,880	1,941	3.74
Yam bean	1	2	0.2	0.2	2,500	578	223	1,922	2,145	4.33
Pickled greens	1	3	0.2	0.2	2,427	430	101	1,997	2,098	5.64
Celery	1	3	0.2	0.2	4,400	1,752	783	2,648	3,431	2.51
Water spinach	2	1	0.12	0.25	5,067	1,707	963	3,359	4,322	2.97

Table 38. Profitability of alternative crops grown on the bund. Unless stated, unit is USD/ha/month.

Crop names	Bund crop (n = 112)	Growing duration (months)	Average area (hectare)	Total area (hectare)	Revenue	Costs	Family labour cost	Gross Return	Net Return	R/C Ratio
Watermelon	5	2	0.12	0.59	1,733	1,196	174	537	711	1.42
Squash	4	2.5	0.12	0.46	2,182	1,479	557	703	1,261	2.04
Corn	12	2.4	0.11	1.33	1,318	537	285	781	1,066	2.54
Winged bean	1	2	0.1	0.1	2,400	1,570	397	830	1,227	1.53
Garlic chives	1	3	0.05	0.05	2,400	1,200	240	1,200	1,440	2
Yardlong bean	3	2	0.15	0.46	3,735	2,535	1,002	1,200	2,202	1.45
Mung bean	1	3	0.06	0.06	2,051	682	287	1,369	1,656	3.01
Pumpkin	2	2	0.1	0.2	2,033	623	263	1,410	1,673	3.97
Bitter melon	8	1.8	0.16	1.28	3,689	1,848	449	1,841	2,290	1.94
Cabbage	3	2.3	0.1	0.3	4,247	1,986	193	2,260	2,454	1.78
Luffa	1	1	0.1	0.1	3,360	1,044	560	2,316	2,876	3.22
Asian greens	3	1.3	0.05	0.15	4,373	2,022	1,146	2,351	3,497	2.29
Okra	3	2.3	0.07	0.2	3,618	1,004	553	2,614	3,167	3.93
Spring onions	33	1.7	0.12	3.89	6,041	3,078	518	2,963	3,481	1.96
Pickled greens	1	3	0.05	0.05	5,333	2,235	179	3,099	3,278	2.39
Tomato	2	3	0.05	0.1	4,240	1,055	661	3,185	3,846	3.92
Cucumber	11	1.4	0.15	1.64	7,145	3,598	1,195	3,547	4,743	1.96
Shallot	1	3	0.1	0.1	6,667	3,120	160	3,547	3,707	2.14
Chili	8	2.8	0.14	1.11	5,948	1,938	881	4,010	4,891	4.11
Lettuce	3	1.3	0.05	0.15	6,400	2,234	902	4,166	5,068	3.2
Chinese cabbage	1	3	0.05	0.05	5,333	487	400	4,847	5,247	10.96
String bean	3	2	0.07	0.2	7,280	2,272	718	5,008	5,726	2.89
Daikon	2	1.5	0.12	0.25	10,020	1,845	650	8,175	8,825	3.81

Table 39. Summary of field and bund crop production area and number of survey responses for different groups of crops grown

Crop group	Varieties	*n*	Total area (ha)	Average area (ha)
Field crops				
Cucurbits	Pumpkin, squash, rockmelon, luffa, gourd, watermelon, honeydew melon, cucumber, bitter melon	108	50.23	0.47
Fruit	Chili, eggplant, okra, corn	33	7.5	0.23
Leafy vegetables	Water spinach, mustard greens, lettuce, pickled greens, spring onions, celery	9	1.38	0.15
Legumes	Yam bean, string bean, mung bean, winged bean	9	1.44	0.16
Other crops	Lotus	2	0.7	0.35
	Sub-total	**161**	**61.25**	**0.38**
Bund crops				
Leafy vegetables	Garlic chives, cabbage, Asian greens, spring onions, pickled greens, shallot, lettuce, Chinese cabbage	46	4.74	0.10
Cucurbits	Watermelon, squash, pumpkin, cucumber, bitter melon, luffa	31	4.27	0.14
Fruit	Corn, okra, chili, tomato	25	2.74	0.11
Legumes	Winged bean, yardlong bean, mung bean, string bean	8	0.82	0.10
Root vegetables	Daikon	2	0.25	0.13
	Sub-total	**112**	**12.82**	**0.11**

7.3.2 Factors influencing the profitability of alternative field crops in the VMD

Table 40. Linear regression model results with field and bund data. Significant coefficients are highlighted as follows: green $p < 0.01$; yellow $p < 0.05$ and orange $p < 0.1$Correlation coefficients between independent variables were all below 0.8, indicating that the assumption of multicollinearity was not violated. Diagnostic plots suggested normally distributed residuals but heteroskedasticity, so robust standard errors were applied. Table 40 presents the results of three linear regression models for each of the Field and Bund data subsets on profitability of crops, measured by the dependent variables Gross Return, Net Return, and R/C Ratio on the 11 independent variables detailed in Table 36. For both field crops and bund crops, all three models were statistically significant at the 99% confidence level. This was despite relatively low R^2 values in both bund and field crop models (Table 40). The R^2 values indicate the percentage of variation in the dependent variable that can be explained by the independent variables.

Table 40. Linear regression model results with field and bund data. Significant coefficients are highlighted as follows: green p < 0.01; yellow p < 0.05 and orange p < 0.1; Robust standard errors are shown in brackets.

	Dependent variable					
	Field data			Bund data		
	Gross Return (1)	Net Return (2)	R/C Ratio (3)	Gross Return (4)	Net Return (5)	R/C Ratio (6)
Education = senior and above	287.22 (135.25)	169.47 (125.29)	0.10 (0.12)	1,188.36 (407.19)	1,077.34 (409.36)	0.86 (0.23)
Growing experience	41.31 (10.19)	31.87 (10.05)	0.02 (0.01)	27.32 (39.87)	33.11 (38.98)	0.04 (0.02)
District = Tran De	14.93 (228.1)	-189.54 (208.24)	0.08 (0.17)	1,717.59 (448.45)	1,718.59 (443.91)	0.65 (0.29)
District = Long My	445.58 (214.32)	383.48 (190.61)	0.64 (0.18)	-1,876.66 (891.5)	-1,722.91 (853.93)	-0.47 (0.69)
Crop area	637.58 (279.17)	595.04 (259.05)	0.66 (0.27)	-13,856.64 (3,291.52)	-14,213.01 (3,386.97)	-8.22 (2.12)
Growing duration	-244.53 (113.0)	-405.10 (95.65)	0.27 (0.08)	-400.42 (340.11)	-958.18 (315.63)	0.15 (0.15)
Information source = family/neighbours	706.74 (190.0)	572.81 (213.33)	0.31 (0.22)	-22.41 (537.78)	140.81 (602.24)	-0.87 (0.75)
Information source = private companies	646.69 (229.86)	604.95 (242.21)	0.31 (0.28)	102.54 (612.28)	258.54 (660.67)	-0.99 (0.76)
Information source = public media	696.80 (288.56)	670.85 (283.32)	0.47 (0.27)	-171.32 (658.68)	15.54 (681.81)	-0.66 (0.83)
Fertiliser	-0.03 (0.13)	0.001 (0.12)	-0.0002 (0.0001)	-0.29 (0.34)	-0.16 (0.31)	-0.0005 (0.0001)
Seed	-0.09 (0.09)	-0.05 (0.09)	-0.0001 (0.0001)	0.06 (0.1)	0.05 (0.1)	-0.0001 (0.0001)
Family labour	0.07 (1.17)	4.48 (1.11)	-0.001 (0.001)	8.08 (2.76)	13.19 (2.82)	0.003 (0.002)
Hired labour	4.65 (2.77)	2.27 (2.38)	0.002 (0.002)	20.44 (11.03)	17.60 (10.9)	0.004 (0.004)
Input access challenge	-30.14 (46.71)	-16.96 (43.69)	-0.003 (0.038)	212.74 (169.81)	83.32 (139.27)	0.07 (0.08)
Constant	105.10 (465.23)	843.65 (464.26)	0.68 (0.37)	1,327.59 (1,158.35)	2,453.71 (1,147.59)	2.60 (1.05)
Observations	146	134	141	106	105	105
R^2	0.38	0.39	0.45	0.37	0.47	0.37

Farmer characteristics

For field crops, respondent households where the highest level of education in the household was senior high school and above achieved significantly higher Gross Return compared to those with lower education levels (Table 40). However, no significant effects of education level were observed in the Net Return and R/C Ratio models. In the case of bund crops, where the education level of households was senior high school level and above there was an even more pronounced significant relationship, with Net Return and Gross Return being higher.

Within the field crop data set, each additional crop season of crop growing experience was correlated with significantly higher Net Return and Gross Return (Table 40). There was also a small but significant increase in the R/C Ratio of 0.02 units. For bund crops, each additional crop season of growing experience was associated with a marginally significant increase of 0.04 units in the R/C Ratio.

Farm system characteristics

For field crops, Gross Return, Net Return, and the R/C Ratio for respondents based in Long My were significantly higher than those in Long Phu (Table 40). While field crops were therefore more profitable for respondents in Long My than in Long Phu, the differences between Tran De and Long Phu were not significant. In contrast, for bund crops, each of Gross Return, Net Return, and R/C Ratio were significantly higher in Tran De than in Long Phu. Bund crops were less profitable in Long My than in Long Phu, but the differences were not statistically significant.

An increase of one hectare in field crop area led to a significant increase in Gross Return, Net Return, and the R/C Ratio (Table 40). In contrast, an increase of one hectare in total crop area of bund crops was correlated with significant decreases in Gross Return, Net Return, and the R/C Ratio.

An increase of one month of field crop growing duration had a significant negative association with both Gross Return, and Net Return, but had a positive association with R/C Ratio, which increased by 0.27 units (Table 40). The Gross Return and Net Return of bund crops also significantly decreased where crop growing duration was one month greater, by USD400.42 /ha/month and USD958.18 /ha/month, respectively. There was no significant relationship between R/C ratio and growing duration for bund crops.

Sourcing production information from family and/or neighbours was associated with significantly higher Gross Return and Net Return for field crops, compared to information from government agencies, at USD706.74 /ha/month and USD572.81 /ha/month, respectively (Table 40). Sourcing information from private companies was likewise associated with significantly higher Gross Return and Net Return for field crops compared to sourcing information from government agencies, at USD646.69 /ha/month and USD604.95 /ha/month, respectively. Use of public media for field crop production information was associated with significantly higher Gross Return of USD696.80 /ha/month, higher Net Return of USD670.85 /ha/month, and a higher R/C Ratio of 0.47 units compared to using information from government agencies. No statistically significant effects were found for bund crops.

There was a small but statistically significant negative effect of increased fertiliser use on the R/C Ratio for both field and bund crops, but no association of fertiliser use with either Gross Return or Net Return (Table 40). Across the two data sets, there was only a slight significant negative effect of increased seed usage on the R/C Ratio for bund crops.

For field crops, an increase of one day in the amount of family labour used to produce crops corresponded to a significant increase of USD4.48 /ha/month in Net Return (Table 40). Increased use of family labour also had significant positive correlations with bund crop production, with an USD8.08 /ha/month increase in Gross Return; a USD13.19 /ha/month increase in Net Return; and an increase of 0.003 units in the R/C Ratio. There was a significant positive correlation of increased hired labour use for field crops with Net Return, of USD2.27 /ha/month. For bund crops, increased hired labour use had significant positive effects on both Gross Return and Net Return, of USD20.44 /ha/month and USD17.60 /ha/month, respectively.

No statistically significant relationships were observed between the profitability indices and how challenging farmers felt it was to access cropping inputs for field or bund crop production. There was a slight negative association between this variable and the three models of Gross Return, Net Return, and R/C Ratio for field crops, and a slight negative association for bund crops.

7.4 Discussion

We found considerable variation in the type of vegetable crops produced as alternatives to rice; farming size; and farming system (field/bund) in the study area. This was accompanied by great variation in crop profitability, both within varieties and across the varieties grown. These results were similar to what Huong et al. (2013a) found in the Red River Delta of Vietnam. Diversity of crops grown and their profitability, within a relatively small sample of farmers, is likely to reflect the wide range of crop options that can thrive under different production conditions in the VMD. Ideally, alternative crops must be adaptable to changing climate, and have the potential to improve on-farm income with respect to rice production (Le et al. 2024a). Maintaining or improving profitability remains a key driver for farmer production system change (Nguyen et al. 2021, Mills et al. 2023), and understanding which alternative crops are more profitable but also what affects their profitability can inform farmer decision making and policy support for the most suitable and profitable alternative crops in the VMD.

7.4.1 Relative profitability of alternative crop options

Though our research identified great variation in the profitability of the numerous alternative field crops covered in the survey, we did not compare the profitability of these options with rice, the dominant field crop of the VMD. Previous studies indicate that year-round vegetable production can be more profitable than either rice-vegetable rotations, or year-round rice cultivation (Huong et al. 2019, Jamal et al. 2022), highlighting the potential of alternative crops to improve climate change resilience the VMD while also enhancing family income and farming livelihoods.

Recent farmer surveys suggest that the declining profitability of rice production is a key driver of the decision of some farmers to abandon rice production in the VMD, with those experiencing profits of less than 20 million VND per hectare (800 USD/hectare) being most likely to exit (Mills et al. 2023, Mills et al. 2025). However, we found that not all farmers surveyed had improved their income by shifting from rice to alternative crop production, as a few cases reported net returns (or profit) below this threshold for both field and bund cases. This might result from market and production risks associated with new crops, which could further reduce farmer income (World Bank 2016c). Thus, we suggest future research examine the associated risks of growing alternative crops, including evolving market and environmental changes to provide insights for policymakers on supporting farmers in adapting to salinity in VMD (Mills et al. 2023).

Future research may compare the profitability of specific alternative field crops (e.g. the most common, most climate-resilient or fastest-growing options) with rice, to help farmers make informed decisions when considering a shift to these crops. This may include evaluating the profitability of selected alternative field crops in the VMD for a full annual field cropping cycle, rather than our research which focused on a single crop within the annual cycle. This would provide a more comprehensive assessment of land productivity, as the varying durations of alternative field crops allow for different numbers of crops to be produced per year, resulting in differences in total annual income (Xiang et al. 2022). Similarly, seasonal weather patterns will impact the yield of crops at different times in the annual production cycle (Poon & Weersink 2011), while market demand and available price for produce is likely to affect relative profitability of particular crops when marketed at different times of year (Huong et al. 2013b). This information is likely to be most relevant to farmers with limited capacity to take up other adaptations to declining rice yield and profitability, such as off-farm employment, establishing a business, fruit cropping or aquaculture. The establishment costs of transitioning from rice to popular alternative crops may also be explored to allow farmers to make an informed choice.

We also found considerable variation in the profitability of the different bund crops grown by farmers in the study area. Bund cropping provides a supplementary income source, but offers other benefits including pest and disease management in rice crops through crop diversification, providing additional produce for more diverse household consumption, and enhancing farm aesthetics (Horgan et al. 2023). Producing alternative crops on the bund may also provide experience in growing these options, preparing farmers for a potential future transition to permanent alternative field crop production. Future research may explore these benefits of bund cropping in more detail, including the extent to which bund crops, grown for commercial sale, may supplement farmer income and improve farm business sustainability. The potential role of growing on bunds as an experimental trial and learning experience for farmers aiming to transition their rice fields to alternative crops should be investigated.

7.4.2 Factors influencing the profitability of alternative field crops in the VMD

Farmer characteristics

For both bund and field crop respondents, we found positive correlations of higher levels of household education (Rahman 2003, Ugwumba et al. 2010), and greater farming experience (Asfaw & Admassie 2004, Masuku & Xaba 2013, Ahearn et al. 2018) with farm business profitability. Education allows farmers to absorb extension messages, to implement new practices more efficiently (Mussa 2015), and to appreciate the benefits of successful diversification and transformation of production system (Liu et al. 2018). Efforts to improve educational opportunities for all farming household members, not just those directly involved in production, could positively impact alternative crop productivity, efficiency and profitability (Mussa 2015).

Education, and crop production experience, are beneficial for farmers transitioning to somewhat unknown alternative crops (Rahman 2003, Tey & Brindal 2015). However, while experienced farmers should be better equipped to make changes, they may also be reluctant to adopt new techniques to optimise production (Tey & Brindal 2015). Provision of tailored production knowledge and training on the production of key alternative crops may help overcome reluctance to change from more traditional production systems, while at the same time addressing limited production experience amongst other farmers.

Farm system characteristics

We found field crops to be more profitable in Long My district, and bund crops more profitable in Tran De district. However, the profitability of individual crops varies across farming systems and districts (Mishra et al. 2009, Poon & Weersink 2011), and even within the districts that were the subject of this research. Spatial analyses might identify patterns in crop production and suitability on the basis of biophysical factors such as local climate, soil type, salinity levels and access to irrigation water (Bhullar et al. 2023). Socio-economic factors at local-district scale will also influence crop suitability and profitability, including: availability of transport networks; distance to markets and buyers; and localised access to inputs (Sánchez et al. 2022). Local variation in these factors means some crops will be more feasible to produce than others at the farm, village or district scale.

Our research indicated a significant effect of economy of scale for field crop production, where larger farm areas were considerably more profitable per hectare (Mishra et al. 2009, Masuku & Xaba 2013). However, contrasting empirical evidence indicates the possibility of inefficiency of economies of scale in terms of climate resilience, food nutrition, and sustainability (Nayak 2018). Large-scale production requires substantial investment, and this may be challenging for smallholder farmers in the VMD with limited financial capacity or insufficient access to labour resources (Tey & Brindal 2015, Kimura 2023), and where land aggregation has improved production efficiencies but occurs sporadically, or may be limited by current government policy (Tu et al. 2021, Van Phan & O'Brien 2022). Cooperative production may address these scale issues (Huong et al. 2013b, Le et al. 2024a), but drawbacks such as inequitable benefit distribution, excessive time spent on perceived irrelevant activities, and limited capacity of cooperative management need to be addressed in order for more farmers to perceive that the benefits of cooperative production of alternative crops may outweigh the costs (Nguyen et al. 2023).

We found that increasing crop area on bunds may not be an effective strategy for enhanced profitability. This form of production is more likely to be a form of supplementary income or domestic food supply in the VMD (Borelli et al. 2017, Horgan et al. 2023). As such, bund crops may not receive the same level of resources and attention as field crops, leading to inefficiencies and potential negative impacts from expansion.

Longer crop growing durations reduced Gross Return and Net Return for both field and bund crops, but saw an increase in the R/C Ratio for field crops. Longer crop durations might pose challenges for both field and bund cropping due to increased input costs, longer payback periods, exposure to production risks (e.g. extreme weather, pests and diseases), and market risks (e.g. price fluctuation, over-supply during peak season). Shorter growing durations enable farmers to produce more crops within a calendar year, potentially maximising total annual income. However, their adoption requires adequate labour, suitable biophysical conditions (e.g. weather, water availability), market demand (Huong et al. 2013b), and that the crop chosen is relatively profitable in its own right over the calendar year (Xiang et al. 2022). Selection of crop based on growing duration will be influenced by a farmer's capacity and willingness to assess and manage these risks.

Extension and information delivery for alternative crops should focus primarily on field crop production, given it will usually be the main source of farm income. Suitable, best practice production information can improve farm business profitability (Masuku & Xaba 2013), however we found that the source of this information may impact alternative crop profitability (Truong et al. 2015, Nikam et al. 2022). In particular, the strong correlation of information sourced from family and/or neighbours with increased farm profitability, compared to official extension sources, may stem from the greater convenience and availability of family and/or farming neighbours as information sources, their relative expertise and experience of farming in the specific local context, and existing localised relationships, knowledge resources and trust (Mekonnen et al. 2022). The limited use of government information sources amongst our response group, and its weaker correlation with profitable field crop production, may reflect minimal government involvement in agricultural extension in Vietnam, particularly in non-rice crop extension (Ngan & Babu 2018, Le 2020). Policymakers and public agricultural extension services may consider ways to leverage the various well trusted private information sources and community networks for information delivery.

We found little significant relationship between increasing fertiliser and seed use, and the three profitability indices. This may have been a result of greater variation in the fertiliser and seed rates used for these crops than might be expected for more familiar crops such as rice, due to relative lack of experience and knowledge and variation in local agronomic requirements. Nonetheless, profitability may be enhanced via research and extension to identify and then promote optimal fertiliser application regimes and seeding rates for commonly grown non-rice alternative crops suitable for both field and bund production in the VMD (To-The & Nguyen-Anh 2021).

Our research indicated that increased use of family labour resulted in greater Net Return for field crops, while increased hired labour use resulted in somewhat higher field crop Gross Return. Family labour likely contributes to increased Net Return for field crops through cost savings, since family labour may be used at zero real cost to the family farming business. However, greater use of family labour in the farm business means that family members have reduced opportunity to seek off-farm income, a growing trend associated with economic diversification in Vietnam (Liu et al. 2020). Increased use of hired labour may enhance the profitability of alternative crops by providing specialised production skills, facilitating larger-scale production, or filling labour shortage gaps during the cropping season (Ninh 2020). An overall strategy for field crop producers to maximise their net return may be to maximise their use of family labour where it does not impinge on opportunities for family members to take up income-generating opportunities outside the family farm, while utilising hired labour to facilitate greater crop yields when it is cost-effective to do so. However, this strategy requires that sufficient hired labour is available to farmers locally at the times they need it. Many potential farm labourers are likely to desire other, more stable forms of employment than seasonal farm work, reducing the immediately available local farm labour workforce (Ninh 2020).

We found no significant relationship between the amount of difficulty farmers have in accessing farm inputs and their profitability, aligning with earlier research (Huong et al. 2013b, Blanc et al. 2016, Ahearn et al. 2018, Devkota & Yigezu 2020), and suggesting that farmers already had sufficient access to inputs necessary for production of alternative crops.

7.5 Conclusions

Production of annual non-rice crops such as vegetables in the VMD is becoming more common in response to climate change-related challenges to the traditional approach of year-round rice production, but also in response to government policy which has promoted more diverse and sustainable farming sector production.

However as our research has shown, there is not only great diversity in vegetable crops currently grown by former rice farmers in the VMD, but there is also great variation in their profitability. This variation occurs between crops but also across crop varieties grown on different farms, and is likely to be considerable from one crop cycle to the next. For emerging crops in the VMD which were generally grown on a small scale relative to rice at the time of writing, such uncertainty makes it difficult for smallholder farmers to make an informed choice as to which vegetable crop may suit their needs.

We have suggested some areas of future research to evaluate the profitability of key vegetable field crops relative to rice, to better understand the establishment costs of these crops, and to evaluate vegetable crop profitability at different times in the calendar year. While this may provide more guidance to rice farmers seeking to transform their production system, we acknowledge that such data will only be broadly representative of trends, particularly for crops that remain relatively small-scale in the VMD at the time of writing. For bund crops, future research may explore the several additional benefits of bund crop farming beyond supplementing household income or food supply.

Perhaps of more ongoing relevance to agricultural researchers, policymakers and educators in the VMD is the information developed from this research regarding the socio-economic, demographic and biophysical factors that influence alternative field and, to a lesser extent, bund crop profitability. In general terms, we found the following factors to be associated with higher profitability of alternative crops in the VMD: more informed, educated and experienced farmers; farmers from particular districts; farmers growing crops on larger parcels of land; producers of shorter duration crops; farmers who relied on neighbours and family for production information; and those who used more family labour likely to produce profitable and therefore sustainable non-rice annual field crops in the VMD.

Spatial analyses might identify patterns in crop production and suitability on the basis of biophysical factors such as local climate, soil type, salinity levels and access to irrigation water. Socio-economic factors at local-district scale will also influence crop suitability and profitability, including: availability of transport networks; distance to markets and buyers; and localised access to inputs (Sánchez et al. 2022).

In addition to a general understanding, already evident in the VMD, that vegetables are a more sustainable option than rice in a changing climate, policymakers and extension practitioners can benefit from our research in terms of helping farmers to understand in broad terms why to grow vegetables in the field instead of rice, which types of alternative field crop might be more profitable and sustainable, and how their profitability may be maximised through best practices for production and marketing. Commercial sale of profitable bund crops can successfully supplement rice farmer income, and may serve as a useful strategy for farmers to gain experience with novel crops before deciding to transition their rice fields to alternative crops. However, more extensive survey research, perhaps focusing on a selection of the more common vegetable crop varieties such as watermelon, cucumber and corn, might be carried out to confirm these influences on crop profitability at a per-crop level, and potentially for different biophysical production zones of the VMD.

Chapter 8. Field assessment of alternative crop profitability

Tran Duy Khanh, Dang Duy Minh, Paul Kristiansen, Jason Condon and Le Thanh Sang

8.1 Introduction

Field trials completed by the project produced harvestable crops. The cost of production of these trials were calculated based on records of inputs and prices received by farmers who sold the crops produced by the trials.

8.2 Methods

8.2.1 Field sites and crop cultivation

Details of the field trials conducted are reported the final report for plant/soil. These trails were conducted from 2021 to 2025 in Soc Trang, An Giang and Hau Giang Provinces (Table 41). Crops grown included maize, watermelon, beetroot.

Table 41. Details about alternative crop field trials.

Commune	District	Province	Date planted	Crop duration (days)	Trial area (m2)
Beetroot					
Lieu Tu	Tran De	Soc Trang	15/01/2021	82	300
Long Phu	Long Phu	Soc Trang	29/01/2021	81	300
Long Phu	Long Phu	Soc Trang	29/01/2021	81	300
Luong Nghia	Long My	Hau Giang	28/06/2021		1500
Lieu Tu	Tran De	Soc Trang	2/01/2022	89	300
Long Phu	Long Phu	Soc Trang	30/12/2022	92	300
Long Phu	Long Phu	Soc Trang	30/12/2022	92	300
Lieu Tu	Tran De	Soc Trang	6/02/2023	114	300
Long Phu	Long Phu	Soc Trang	15/02/2023		300
Vinh Vien A	Long My	Hau Giang	5/05/2023		750
Lieu Tu	Tran De	Soc Trang	26/01/2024		300
Long Phu	Long Phu	Soc Trang	1/02/2024		300
Long Duc	Long Phu	Soc Trang	25/01/2024	76	500
Tan Thanh	Long Phu	Soc Trang	15/02/2024	65	500
Tan Hung	Long Phu	Soc Trang	5/02/2024		500
Vinh Vien A	Long My	Hau Giang	22/01/2021	83	750
Maize					
Lieu Tu	Tran De	Soc Trang	15/01/2021	75	300
Long Phu	Long Phu	Soc Trang	29/01/2021	68	300

Luong Nghia	Long My	Hau Giang	28/06/2021		1,500
Lieu Tu	Tran De	Soc Trang	2/01/2022	69	300
Long Phu	Long Phu	Soc Trang	30/12/2022	72	300
Lieu Tu	Tran De	Soc Trang	6/02/2023	71	300
Long Phu	Long Phu	Soc Trang	15/02/2023	77	300
Vinh Vien A	Long My	Hau Giang	5/05/2023	62	750
Vinh Vien A	Long My	Hau Giang	5/05/2023	62	750
Lieu Tu	Tran De	Soc Trang	26/01/2024		300
Long Phu	Long Phu	Soc Trang	1/02/2024	63	300
Vinh Vien A	Long My	Hau Giang	22/01/2024	58	750
Vinh Vien A	Long My	Hau Giang	22/01/2024	58	750
Watermelon					
Long Phu	Long Phu	Soc Trang	29/01/2021	61	300
Long Phu	Long Phu	Soc Trang	30/12/2022	65	300
Vinh Vien A	Long My	Hau Giang	5/05/2023		750
Vinh Vien A	Long My	Hau Giang	22/01/2024	56	750

8.2.2 Measurements and data analysis

Crop yield was recorded at harvest on a per plot basis. These data were then converted to standard units of tonnes per hectare.

The farmers that owned the farmers where trials occurred were able to sell the crops produced and the prices received were reported and converted to a standard of VND per hectare.

Costs of production were collated based on project team and farmer inputs and profit or loss calculate on the basis of revenue minus total costs incurred per crop type.

8.3 Results

There was a range of crop outcomes over the duration of the field trials (Table 42). For example, of the trials established, maize (n = 13) failed in 15% of the trials, beetroot (n = 16) failed for 38% of the trials, and watermelon trials (n = 4) failed by 25%. These crop failures were either due to location; e.g. Hau Giang after suffering heavy rainfall due to a typhoon or due to experimental treatment, e.g. late timing of sowing at Long Phu, which pushed crops into a terminal salinity event. In most years, crops were harvested with yields responding to soil and irrigation treatments and returned high profit per hectare (Table 42).

Table 42. Variation in profitability of alternative crops

Crop	Data included for each crop	n	Profit/loss (VND million/hectare) Minimum	Average	Maximum
Beetroot	All trials	16	-45.0	13.1	198.0
	Yielded trials	10		39.3	
Maize	All trials	13	-27.3	49.9	84.7
	Yielded trials	11		63.6	
Watermelon	All trials	4	35.3	54.4	120.1
	Yielded trials	3		83.6	

The specific breakdown in comparison to rice production is evident at Long Phu based on 2022 data, when rice was grown adjacent to the project field trials. The upland crops grown out performed rice on an economic basis (Table 43) with beetroot providing a large economic benefit to the farmers.

Table 43. Economic efficiency of upland crops relative to rice based on 2022 field data at Long Phu, Soc Trang.

	Rice	Beetroot	Maize	Watermelon
Yield	5.7 t ha^{-1}	40 t ha^{-1}	20,160 fruit	5.9 t ha^{-1}
Price/ unit	5,100đ	8,000đ	10,000đ/3 fruits	11,000đ/kg
Total cost	13,080,000	58,632,000	46,404,000	36,850,000
Total income	29,070,000	320,000,000	67,200,000	64,900,000
Profit	15,990,000	261,368,000	20,796,000	28,050,000
Profit increase (%)	**0%**	**163%**	**25%**	**75%**

8.4 Discussion and conclusion

Crops that are currently grown in the VMD (i.e. maize, watermelon) had a lower risk of crop failure compared with newly introduced crops and which are not generally suited to cultivation in tropical areas such as beetroot and quinoa (Directorate Marketing 2021). The risks associated with growing new crops include the water use behaviour of neighbouring farmers and weather extremes such as heat, which prove difficult to predict. However, the trials demonstrated that when soil management and irrigation practices are employed, crop success is possible and profitable. The field experiments of the FOCUS project provide confidence that alternative crops to rice can be economically beneficial to farmers, especially as an alternative to seeking off farm income thus alternative crops provide benefit to livelihood of small holder farmers in the MRD. Beetroot remains a standout performer in terms of agronomic production per hectare and profit per hectare. The development of supply chains and post-harvest processing should provide score for expansion to scale in the MRD.

Chapter 9. Value chain development for new crops

Le Thanh Sang, Paul Kristiansen and Michael Coleman

9.1 Introduction

Climate change poses significant challenges to agriculture and farmer adaptive capacity. The Vietnamese Mekong Delta (VMD) is an especially vulnerable region, facing climate challenges that increase farm productivity (Ho et al. 2021, Tran et al. 2023). Climate-change-induced challenges such as increasing drought and salinity have led to declining year-round rice production yields (Kaveney et al. 2023, van Aalst et al. 2023b). In response, farmers are increasingly shifting to alternative crops, such as vegetables and various fruit crops. in order to diversify their incomes or more away from crops that are less profitable or more vulnerable. This is occurring in line with Government of Vietnam policy aiming to support this transition, to sustain agricultural productivity and livelihoods (Government of Vietnam 2021, MARD 2023).

The FOCUS project aims to promote alternative crops (e.g. beetroot and quinoa) in the VMD that may improve farmer resilience to the impacts of salinity. However, at the time of writing, markets for these crops were either in their infancy or non-existent, posing challenges for farmers seeking economically viable alternatives to their current production systems. Farmers are unlikely to adopt a new crop unless they can see that there is access to a stable and profitable market for the produce.

Output markets for these alternative crops remain underdeveloped, and there is limited understanding amongst farmers and others in the value chain regarding how to effectively operate within these emerging markets (Kim 2016, Turner et al. 2019). Although there are promising examples of successful crop diversification (Hua & Brown 2024, Le et al. 2024b, Huỳnh 2025), smallholder farmers face numerous challenges.

The FOCUS HHS and a review of the literature were utilised to inform market development strategies that support the successful introduction of new crops in the VMD. The specific research questions included:

1. What marketing support, assistance and advice is available to sell novel crop produce?

2. How does increasing production scale impact the prices of novel agricultural crop produce?
3. What other factors influence price changes in immature agricultural value chains as production scale expands?
4. How do prices differ before and after processing as production scale increases for novel agricultural crop produce?

9.2 Methods

Please refer to Section 2.2 for details of the methodology for the first research question in this chapter, which was addressed using the HHS. The methodology to collect the HHS data presented in Chapters 2, 4, 5, 6, 7 and 9 was identical.

A narrative literature review was also completed to address the second, third and fourth research questions of this chapter.

9.3 Marketing support and assistance

Farmers may choose to engage the assistance of experts outside the household to assist them in marketing their crop in order to obtain a higher price. The interviewees were asked to consider several potential arrangements which they may currently utilise in order to market their crops with buyers, and for how many cropping seasons (of which there may be several per calendar year depending on crops grown) each arrangement had been in place (Table 44).

The results show that membership of a farmer collective was the most common method by which households worked with others to market their crops (over 38% of all interviewees). Farmer co-operative membership was the next most common arrangement, but involved less than 5% of interviewee households. Only 2% of interviewee households sought marketing assistance from government departments, though this arrangement was the most long-standing having been in place for just under 20 cropping seasons on average for those using this approach to marketing support. None had a contract in place with a company. 'Other' arrangements, where indicated, referred to arrangements such as the 'One Commune, One Product' approach which operate with support of the government but also usually involving a company and/or co-operative. Only one respondent was considering changing their current marketing arrangements (currently working with an unspecified organisation) to increase the price obtained for their crop.

However, it is relevant to note that more than half of all interviewee households had no marketing arrangements in place at all. This suggests that there may be an opportunity to link a greater proportion of households with external marketing support, to obtain a higher price from buyers than may be possible under circumstances where the farmer negotiates directly with the buyer.

Table 44. Proportion of interviewee households having certain arrangements currently in place with organisations to assist with the marketing of their crops, and number of cropping seasons arrangements have been utilised

Current arrangements to assist with marketing of crops	All interviewees (%; n = 299)	Mean years utilised	Std dev years utilised
Membership of farmer collective	38.50	9.45	8.08
Membership of a farmer co-operative	4.30	6.08	4.96
Assistance from government departments	2.00	19.50	32.81
A contract with a company	0.00	–	–
Other arrangements	3.00	6.56	4.72

Although none of the survey participants had a contract in place to market their crops (Table 44), enumerators and project research team members recorded a variety of advantages and disadvantages of contract farming, e.g. through a farming group which provides farmers with a collective strength in negotiations with buyers. The list of advantages and disadvantages are based on enumerator observation as well as discussion with farmers and staff from DARD, and are summarised in Table 45. Additional information provided by DARD indicates that farmer contract arrangements in the Long My district covered 10,606 ha out of 16,901 ha of farm area. In some cases, companies only offered contracts for rice because upland crops were relatively perishable. Seed suppliers likewise did not tend to offer contracts for upland produce, but they did aim to connect farmers to traders to facilitate purchase. Farming contracts tended to specify higher quality standards, and involve delayed payment to farmers. Farmers may instead prefer less formalised purchase arrangements that involved cash on delivery of harvested produce. Contracting organisations may include local farmer groups (often of considerable size such as the Loc Troi Group) as well as small-to-medium companies based elsewhere in the Mekong Delta or further afield.

Table 45. Advantages and disadvantages of contract farming

Advantages	Disadvantages
Price received may be greater than that achievable if going direct to market – but not significantly so.	Contracting organisations may impose strict quality guidelines on farmers for their crop, e.g. proportion of ripe seeds; moisture content; rice grain length. If these

	criteria are not met, then the price given to the farmer will be reduced.
By contracting to a group, farmers are less likely to face price squeeze by buyers.	Payment procedures may be complex and slow relative to direct engagement of farmers with buyers.
The contracting organisation (e.g. farming group) may provide more affordable production inputs than farmers would be able to source by themselves.	Farmers may be locked in to purchasing all farm inputs from the organisation with which they have signed a contract, rather than being able to 'shop around'.
Organisations to which farmers are contracted may provide training opportunities and support (e.g. planting, crop management) and access to new production techniques (e.g. using drones to apply pesticide).	

Those that did have arrangements in place to market their crops were asked further to indicate:

- How cost-effective these arrangements were.
- How satisfied the interviewee/their household was with the arrangements.
- The advantages and disadvantages of the different types of arrangement.

Overall, interviewees indicated both relatively high levels of cost effectiveness and satisfaction with the organisations they worked with to market their crops (Table 46). The advantages and disadvantages of the various arrangements as perceived by interviewees are summarised in Table 47. Relatively limited information was provided, and much of it is associated with benefits of these organisations in areas other than marketing – suggesting that the interviewees on the whole did not tend to consider specific details with respect to marketing arrangements. This suggests that the scores of cost effectiveness and satisfaction summarised in Table 46 are also often likely to have been provided with consideration of aspects of farming other than marketing.

Table 46. Levels of cost effectiveness and satisfaction with arrangements currently in place with organisations to assist with the marketing of crops, where 1 = 'not cost effective/not satisfied', and 5 = 'very cost effective/very satisfied'

Current arrangements to assist with marketing of crops	Mean cost effectiveness	Std dev cost effectiveness	Mean satisfaction	Std dev satisfaction
Membership of farmer collective (n = 115)	3.95	1.01	4.62	0.66
Membership of a farmer co-operative (n = 13)	4.31	0.75	4.46	0.52
Assistance from government departments (n = 6)	4.50	0.84	4.83	0.41
A contract with a company (n = 0)	–	–	–	–
Other arrangements (n = 9)	4.44	0.73	4.56	0.53

Table 47. Summary of the advantages and disadvantages of the different arrangements currently in place amongst interviewee households to assist with marketing crops

Arrangements to assist with marketing of crops	Summary of advantages	Summary of disadvantages

Membership of farmer collective	Ease of locating trader; shared experiences and learn from other farmers; access to training, technical support, plant stock/agronomic advice; credit	Inexperience
Membership of a farmer co-operative	Improve technical/farming skills; share experience with other farmers; financial support	–
Assistance from government departments	Access to technical information on farming; access to training and improve knowledge; information about new varieties; information about the market	–
A contract with a company	See Table 45 for details	See Table 45 for details
Other arrangements	Establish a co-operative approach; support with production inputs	–

9.4 Marketing training and advice

None of the interviewees indicated that they had received marketing training or advice at the time the survey was carried out, however a small number of interviewees noted that they would like to receive training in how to sell their crop, including training in online sales (e.g. Facebook, Zalo).

Preferred providers of training or advice in marketing included:

- Department of Agriculture and Rural Development extension staff
- other extension providers, including local training programmes
- those involved in farmer collaborative efforts, including farmer co-operatives or unions, and farmer commune staff, and
- general media.

9.5 Scale and prices

9.5.1 Economies of scale

Economies of scale refers to the reduction in average production costs per unit as farm output increases. Larger farms therefore typically achieve lower per-unit costs compared to smaller farms (Duffy 2009, de Roest et al. 2018). Therefore, as production of new crop varieties expands, the cost of production per unit of output decreases, reducing prices and potentially increasing demand (van Aalst et al. 2023b). Many farmers in the VMD are smallholders, with limited financial capital and entrepreneurial capacity. This creates a potential need for some market coordination to build negotiating power among farmers, increase supply volumes and share costs and risks. Achieving efficiencies of scale is challenging for smallholder farmers without support through cooperatives or collective actions (Islam et al. 2015, Hua & Brown 2024, Trang & Tu 2024).

It is important to note that policies and projects to support crop diversification have often focussed on production, while neglecting the arguably more important role of market development, including strategies such as infrastructure, value chain development, models for scaling up, and fostering public-private partnerships (PPP) (Nandi et al. 2024). Scaling up novel crops in the VMD requires coordinated efforts across policy, investment, and innovation. Provincial Departments of Agriculture & Rural Development (DARD) support crop production among farmers through policies and mechanisms, as well as connecting the private sector with farmers in vertical or multi-dimensional coordination involving DARD, scientists, businesses, and farmers. The private sector plays a key role in stabilising markets through contract farming and supply chain investment, while start-ups and business incubators drive innovation, expand opportunities for micro, small and medium enterprise (MSMEs), and strengthen market linkages. These combined efforts enhance value chain efficiency, attract investment, and accelerate the adoption of novel crops.

9.5.2 Price transmission

Price transmission refers to the fact that as prices change in one segment of the supply chain, there are flow-on impacts on prices at other stages, for example from the farm gate to wholesale and then retail markets (Assefa et al. 2015, von Cramon-Taubadel & Goodwin 2021). While increased production generally leads to lower prices, the prices that farmers receive at the farm gate – where agricultural products are sold directly by farmers to wholesale traders before reaching the retail market – will often decline more sharply than wholesale prices; that is, the price that retailers pay when purchasing farm produce in bulk from wholesale suppliers. This sharper decline occurs because farmers have weaker bargaining power, limited storage options for their produce, and face an urgency to sell perishable farm produce, whereas wholesale traders have sufficient storage available to allow for gradual price adjustment (Nguyen et al. 2016). Price squeezing is also common due to the monopsony power held by small groups of traders (Hoang & Nguyen 2023, Le et al. 2023b). Limited on-farm processing capacity further constrain the capacity of farmers to negotiate better prices (Poulton et al. 2006). Strengthening the direct access of farmers to retail markets and collective bargaining efforts are crucial to ensuring a more equitable distribution of the benefits of increased production (Ma et al. 2024).

9.6 Market signals

Farmers are highly responsive to market signals, including price trends, demand shifts, and changes in policy (van Aalst et al. 2023b, Le et al. 2024b, Ma et al. 2024). These changes widely impact individual and family livelihoods, impacting income stability, labour allocation, and household sustenance, while shaping the region's agricultural systems (Mergenthaler et al. 2009, Huong & Yorobe 2017, Vu 2020). Elastic demand, where consumers adjust the quantity they purchase in response to price changes (Roberts & Schlenker 2013), leads to large shifts in demand, influencing the production decisions of farmers and the quantity of agricultural products they cultivate. On the other hand, when demand is inelastic, it remains stable despite price variations, so farmers continue producing at consistent levels. Limited adjustments to supply in response to price signals can create imbalances when demand fluctuates, leading to price instability or lower farm-gate prices, especially if excess supply pushes prices down (Kirkden et al. 2003, Andreyeva et al. 2010, Vukadinović et al. 2017). Balancing supply and demand, for example through contracts or demand forecasting, is critical to ensuring relative stability in markets, and to maintain farmer incomes at relatively consistent levels (Yadav et al. 2021).

9.7 Market development

Market development is especially relevant to the relatively new, immature and small markets that are likely to exist in the VMD for crop varieties that are more recent introductions in Vietnam. In the early stages of new crop production, supporting infrastructure, crop inputs, production experience and knowledge, logistics, and marketing channels for alternative crops are often underdeveloped or in limited supply (Ma et al. 2024). This can reduce profitability, contribute to unstable prices, and potentially reduce the willingness of farmers to take the risk of adopting a new crop (Dethier & Effenberger 2012, Sadik-Rozsnyai & Bertrandias 2019).

Improving value chains and ensuring access to stable, large markets is essential for the long-term success of novel crop adoption. Market expansion increases the number of buyers, creating more opportunities for farmers to sell their produce at competitive prices. This helps to stabilise demand, prevent local oversupply and stabilise prices (IMF & UNCTAD 2011). Building demand through activities such as advertising (online, media and in public spaces), branding strategies (e.g.

One Commune One Product [OCOP]), targeted promotional events and food expos[1] are important, although many of these options are not realistic for smallholder farmers. However, farmer groups, cooperatives and SMEs (small- and medium-sized enterprises) can play a useful role in increasing product awareness and demand (Hua & Brown 2024, Le et al. 2024b). Reaching more buyers allows helps to increase farmer willingness to diversify income sources and lower the risk of financial losses if demand fluctuates in any single market (Shepherd 2007). At the same time, improving distribution systems can reduce transaction costs for both farmers, traders and retailers, ensure timely delivery, and minimise losses, contributing to a more stable and efficient agricultural market (Yadav et al. 2022).

Together, these factors strengthen the value chain, making it more resilient and sustainable. Mature and expanding markets benefit from consumer awareness, brand promotion and recognition, scaling, and improved operations. In emerging economies like Vietnam, where growth in the numbers of middle-class consumers has increased demand for processed food products and has led to a gradual rise in prices (Hansen 2018, Pingali & Abraham 2022). Where there are improved supply chains, expanded markets, and efficient distribution, farmers are more likely to have access to buyers and to be faced with reduce costs – thus, price increases are more likely to benefit farmers directly rather than be absorbed by wholesale traders.

9.8 Impacts of processing on price

The price of agricultural products **before processing** is largely influenced by supply and demand dynamics. If an increase in production is not met by an accompanying or greater increase in demand, the result is a surplus of the product and therefore reduced per-unit price (Huka et al. 2014, Võ 2016). In contrast, demand may rise in line with or greater than the rate of supply, due to societal trends; product substitution; or increasing desirability of a product due to innovations in farming techniques and product development. In these cases, prices will remain stable or even increase (Trostle 2008, Roberts & Schlenker 2013).

Market entry and competition also shape price fluctuations before processing. Increased production capacity often attracts new entrants into a market, increasing competition among

[1] For example: https://foodexpo.vn/en/index.php, https://foodanddrinkshow.com.vn/

producers of the same good or service. This competitive environment can initially drive prices down as businesses vie for a finite market share. However, the long-term effects of increased competition on prices will depend on several factors, including market regulations, the level of differentiation in products offered by the growing number of sellers, and the presence of barriers to entry (Gonsalves et al. 2022).

Processing plays a critical role in shaping agricultural prices by adding value to raw products. It significantly enhances the value of agricultural products, enabling producers to access markets that are less sensitive to price volatility than for unprocessed goods. Relative price stability is more likely to exist for processed goods as a consequence of branding, extended shelf life, and established consumer demand, which contribute to a more reliable market (Ahmad & Anders 2012). As processing scales up alongside increased production of the unprocessed product, per-unit costs are often reduced through economies of scale, increasing availability to consumers of processed goods at competitive prices (Vorley et al. 2009, Samper et al. 2017). However, when processed products cater to niche or premium markets – such as organic or specialty food sectors – price points can remain high or even rise, despite an increase in production (My et al. 2018).

The relationship between raw material supply and availability of sufficient processing infrastructure is also crucial. If processing capacity does not keep up with production, supply bottlenecks can lead to price volatility. In contrast, well-developed processing infrastructure can help to stabilise prices by ensuring a steady flow of processed goods to the retail market (IMF & UNCTAD 2011, Melas et al. 2024). In Vietnam, the modernisation of processing plants has supported smoother transitions between raw and processed products, reducing price fluctuations (Melas et al. 2024).

9.9 Conclusions

Climate change will have profound impact on agriculture in the VMD, where drought and salinity has brought into question the long-term viability of the dominant year-round rice production system. In response, farmers are shifting to alternative crops, such as vegetables and fruit, in line with government policies aimed at sustaining agricultural productivity and livelihoods. The FOCUS project is promoting beetroot and quinoa production to enhance farmer resilience to salinity impacts, although the markets for these crops are still underdeveloped. Farmers are reluctant to adopt new crops without access to stable, profitable markets, and there is a limited understanding of how to navigate these emerging markets effectively. This report sought to identify some of the key issues faced in marketing novel crops.

Our survey of farming households indicated that membership of a farmer collective was the most common source of support and method by which farmers surveyed marketed their crops. None of the farmers surveyed had signed a contract with a buyer. Where respondent farmers did have support of an external organisation (such as a collective) to market their crops, they indicated on average relatively high levels of cost effectiveness and satisfaction with these arrangements. However, over half of all farmers had no marketing arrangements in place, indicating an opportunity to link more farmers with external marketing support.

While none of the farmers surveyed participated in contract farming, respondents did provide their thoughts on the advantages and disadvantages of contract farming. Price stability and access to additional resources such as farm inputs and training counted amongst the advantages; while strict quality guidelines, slow payment procedures and being “locked in” to an arrangement were noted amongst the disadvantages.

None of the farmers surveyed indicated that they had received training or advice in the area of marketing, but some did note that they would appreciate training in sales pathways, including online marketing, and that this would be welcome if provided by DARD, other extension providers, and other members of farmer collectives or co-operatives.

Our review of the literature suggests that increasing the production scale of novel agricultural crops can be expected to reduce per-unit costs. This effect is likely to benefit larger farms through economies of scale, though for smallholder farmers scaling up production presents its own challenges due to weak bargaining power, limited storage capacity, and restricted retail market access. As production increases, these farmers may also experience sharper declines in farm-gate prices compared to wholesale prices, in part due to the limited capacity of smallholders to store perishable crops and the monopsony power of traders. Ensuring the equitable distribution of benefits from increased production of novel crops will require improvements such as greater direct market access, more promotion and advertising, and strengthened collective bargaining, including producing through cooperatives (horizontal coordination) and contract farming (vertical coordination), to enhance the economic outcomes of smallholders in the VMD.

Price fluctuations in immature agricultural value chains are shaped by market signals such as price trends and demand shifts, and influence farm production decisions and farming family income stability. Emerging crop options are likely to face price instability relative to established crops, due to underdeveloped supporting systems including infrastructure, logistics, and market access. Elastic demand will amplify the impact of minor price changes on production, while inelastic demand will heighten the risk of oversupply and lower farm-gate prices. Expanding markets, improving infrastructure, and enhancing distribution networks can facilitate and stabilise demand, reduce transaction costs, and make it easier for farmers to adopt and profit from novel crops. Strengthening these value chain linkages can further ensure that price increases are more likely to benefit farmers rather than to be absorbed by intermediaries. These measures will help to create more resilient, sustainable and diversified markets for agricultural produce.

Previous research indicates that as production of novel crops scales up, price differences emerge between unprocessed and processed agricultural crops. Before processing, the prices of novel crops fluctuate with supply and demand, with increased production driving prices down unless matched by rising demand. Farmers remain vulnerable to price instability, particularly when market access and storage facilities are inadequate. Processing adds value through branding, extended shelf life, and expanded consumer demand, contributing to greater price stability. However, without sufficient processing infrastructure for novel forms of produce and novel markets for processed forms of such produce, supply bottlenecks may still lead to volatility. Expanding market access and processing capacity of crops that are new to the VMD may be achieved by aligning overarching programmes (e.g. OCOP) with local government development initiatives such (e.g. Rural Youth Entrepreneurship Project). Integrating and adapting existing support strategies to stabilise value chains for new and emerging crops can smooth the market pathways for farmers and facilitate the up-scaling of production.

Saline-tolerant crops that are new to the VMD may offer viable farming systems diversification alternatives, not only to dry season rice but also to more established vegetable and fruit crops. Successful adoption, however, will rely on stable markets as production expands. Enhancing market access, processing capacity, and value chain integration is needed to improve income stability for producing novel crops such as beetroot and quinoa, and making these alternatives more attractive for smallholder farmers in the VMD to adopt.

Chapter 10. Case studies of successful crop-based companies in the VMD

Ngo Thi Thanh Truc, Chung Thi Ngoc Hue, Paul Kristiansen and Michael Coleman

10.1 Introduction

This report summarises the activity to identify and analyse market and governance components of successful crop-based industries in the Mekong Delta. It is an initial assessment to identify relevant institutions in the wider agricultural industry, and social factors and institutions that enhance or stifle the adoption process. The core project team have worked with government and business to select participants (stratified purposive sampling) for a series of household surveys (HHS) key informant interviews (KIIs) and focus group discussions (FGDs) with value chain stakeholders from farmers to retailers and supporting stakeholders in government and NGO sectors.

The HHS, KIIs and FGDs acquired data about drivers and barriers in production, marketing, organisational structures and policies. Analysis and reporting have involved (i) a thematic approach exploring issues such as common constraints and enabling factors, private sector engagement, gender participation/access, and governance arrangements (e.g. land ownership), and (ii) putting the analyses in context regarding how generalisable the findings are, how they compare to other research, and their policy implications. Finally, case studies of successful agribusiness companies or groups, such as input suppliers (e.g. crop protection, machinery), traders and processors allow identification, and provide illustrative examples, of the key components required in the cropping systems diversification process in the VMD.

10.2 Methods

HHS, KIIs and FGDs were carried out to identify constraints and successful commercial and policy strategies to facilitate diversification. A summary of data collection activities which have conducted or are planned (Table 48). Human research ethics approval for the research was obtained from the University of New England (HE22-004) in February, 2022.

Table 48. Summary of data collection activities conducted or planned

Crops	Cases	Company	Notes; key findings	Status
Green soybean	Tan Trung Co-op	Antesco	Co-op development	Done
Baby corn/cattle	Hoi An Co-op	Antesco	Co-op development	Done
Milky apple	Loc-Mai Co-op	T&T	Co-op development	Done
Milky apple (new variety)	Xom Dong 2 Co-op	T&T	Co-op development new varieties	Done
Pumpkin, rockmelon, processed products	Bao Gia Research Farm	Hai Au	From research to market (all private involvement)	Done
Seasonal fruits, value-added products	ABAVINA	ABAVINA	Climate smart agriculture, but small scale/community scale	Done
Rice	Hung Loi Co-op	Ong Tho	From 2019	Done
Rice	Loc Thanh	Loc Troi	2021 (6 crops)	Ongoing
Rice	An Binh Co-op	Loc Troi	From 1996	Ongoing
Rice	Broker/Middlemen	?	Common, control case	Ongoing
Rice straw/cattle	Tan Hung CSV	?	Change in rice straw uses	Planned

"Successful cases" were identified by the authorities of Sub-DARD and experts. "Successful" means collaboration or transaction between the cooperatives, producers and enterprises, the consumption or processed companies successful or in operation for some years. The process to identify the successful cases was conducted first by key informant interviews the Sub-DARD staff and experts about the successful cases of cooperatives, groups of farmers or farms to the consumption or processing companies (Figure 15). The priority of the cases chosen was first cash crops (melon, green bean, baby corn, etc.), then rice and fruit. From these talks, we obtained lists of cooperatives or companies (46 cooperatives). We first short listed the best proposed cases from each province or group of crops and conducted phone interviews with these cooperatives and companies (16 cooperatives). From the results of the phone interviews we chose 6 cases/group of cases with whom we conducted in-depth interviews. The first face – to – face meetings were mostly conducted with the head of farmer cooperatives, with their management boards or main staff (Bao Gia Farm). Then, we identified the main actors in each case and conducted interviews with them to enrich the information of each case and confirm the information we obtained from the phone and first face – to face meetings and field visits for each case. The adaptive process was conducted based on the information collected from each case.

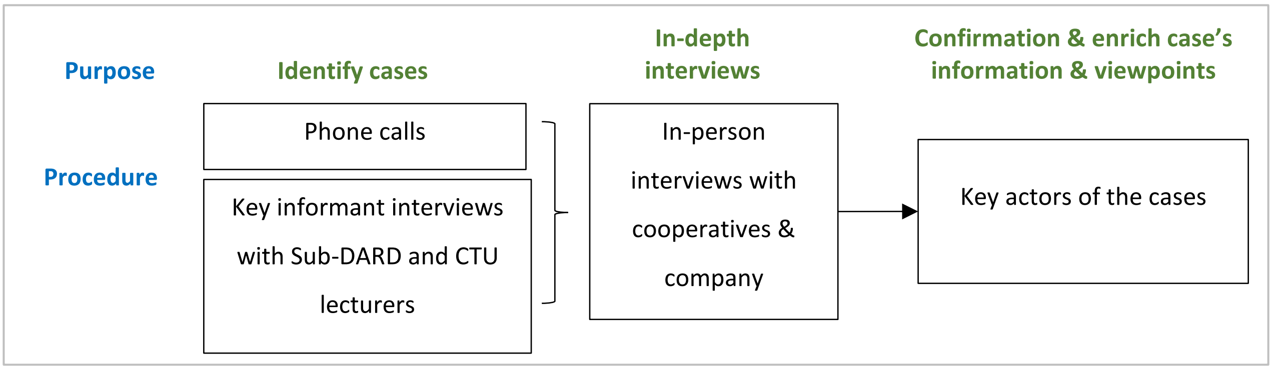

Figure 15. Process to identify successful cases of market or private engagement

10.3 Results

10.3.1 Business models

From the six cases there are three group of business models. First of all, cooperatives are the most favourable in the local authorities. The idea of this model is to gather small farmers into the cooperatives. The cooperatives are the representative of farmers in dealings with input and output agents to improve farmer efficiency and provide a collective voice. The successful cooperatives cases in this report were selected from hundreds of cooperatives in the Mekong Delta, especially in Soc Trang.

The second business model is a community-based approach introduced by ABAVINA Corp. ABAVINA at first is a group of farmers linking crop production with consumption at end markets. Instead of converting to cooperatives, ABAVINA was established as a corporation. They pursue climate agriculture technologies with organic farming orientation, adopt indigenous knowledge in farming, and create opportunities to generate income for farmers from all products of their farms, not only on the basis of single products, like 3 rice crops per year or 1-2 fruit harvests per year. ABAVINA has a vision to develop their company; however, due to lack of resources, they have not successfully expanded their business scale or increased the number of farmers in each community or new communities.

The third business model is the private Hai Au corp. They fully invest from research to market activities. The first visit to Ba Gia Farm, a research farm belonging to Hai Au Corp because they were impressed with growing rockmelon, on type of cash crop that the research group prioritising for interview. Then, we found this one promising business model that can be used to disseminate or upscale the cash crops introduce by FOCUS. The private investment deals with efficiency, so they react quite fast with changes in the market and thus, helped us screen the activities as well as to identify trends in how these business models may be able to develop or expand.

These are three business model that FOCUS can choose to upscale the crops that may be introduced at the end of the project. All three of them have both advantages and constraints at present and in the future.

10.3.2 Descriptions and illustrations of the market and enterprise engagement cases

Tan Trung cooperative (Green Soybean)

Figure 16. Meeting Mr Nguyen Van Bo, head of Tan Trung cooperative, Tan Hoa commune, Phu Tan district, An Giang. Left to right: Chung Thi Ngoc Hue (School of Economics, CTU), Mr Nguyen Van Bo (head of Tan Trung Cooperatives, mainly produce green soybean and sell to Antesco), Dr Ngo Thi Thanh Truc (School of Economics, CTU). Date: Sept 7, 2023 at Home Coffee shop in Tan Hoa commune.

Figure 17. Field visit with farmers who have not joined in the Tan Trung Cooperative in Phú Mỹ commune, Phu Tan district, An Giang province, Vietnam. Left to right: Mr Nguyen Van Bo (Head of the Tan Trung cooperative), Mr Nguyen Phuoc Thoi (grows cucumber), Mr Nguyen Ngoc Hoa (grows sweet corn and pumpkin), Mr Tai (grows cucumber), Ms Chung Thi Ngoc Hue (School of Economics, CTU). Date: Sept 13, 2023 at upland crop farm after interview farmers in Tan Hoa commune.

Figure 18. LEFT: Green soybean at one of farms grown by farmer who is member of Tan Trung cooperative, Phu Tan district, An Giang province. Source: Picture shared by Mr Nguyen Thanh Nam, staff of Antesco who monitor green soybean growing in Phu Tan district, An Giang province, Sept 13, 2023. RIGHT: Green soybean right after harvest. Source: Picture shared by Mr. Nguyen Thanh Nam, staff of Antesco who monitors green soybean growing in Phu Tan district, An Giang province, Sept 13, 2023

Figure 19. Final product of green soybean at Antesco website (Source: Antesco website).

An Hoi cooperative, Ha An Commune, Cho Moi district, An Giang province

Figure 20. Meeting Mr. Tran Cong Nghe, head of Hoi An cooperative, Hoi An commune, Cho Moi district, An Giang. Left to right: Dr Ngo Thi Thanh Truc (School of Economics, CTU), Mr Tran Cong Nghe (head of Hoi An Cooperative, mainly produce baby corn and sell to Antesco), Chung Thi Ngoc Hue (School of Economics, CTU). Date: Sept 7, 2023 in front of Mr Tran Cong Nghe's house, near the office of Hoi An cooperative.

Figure 21. Meeting Mr. Tran Cong Nghe, head of Hoi An cooperative, Hoi An commune, Cho Moi district, An Giang. Left to right: Dr Ngo Thi Thanh Truc, Mr Tran Cong Nghe (head of Hoi An Cooperatives, mainly produce baby corn and sell to Antesco), Chung Thị Ngọc Huệ. Date: Sept 7, 2023 in front of the Hoi An cooperative office.

Figure 22. LEFT: Baby corm at farm near Hoi An cooperative, Cho Moi district, An Giang province. Source: Picture shared by staff of Antesco who monitor green soybean growing in Phu Tan district, An Giang, Sept 13, 2023. RIGHT: Baby corn sorted at the Hoi An cooperative before transferring to Antesco, Cho Moi district, An Giang.

Xom Dong 2 cooperative – Milky apple – new variety

Figure 23. Cooperative Xom Dong 2, Thoi An Hoi commune, Ke Sach district, Soc Trang, province. The product of this cooperative is Bo Hong milky apple, a new milky apple variety. This cooperative is far from the main road. However, it has strong interest from Soc Trang province government staff, with the strategy to establish the cooperative and sell milky apple to supermarkets.

Figure 24. LEFT: Picture of milky apple trees growing in Xom Dong 2, cooperative, Thoi An Hoi commune, Ke Sach district, Soc Trang province. RIGHT: Bo Hong milky apple after sorting at Xom Dong 2 cooperative in Xom Dong 2, Thoi An Hoi commune, Ke Sach district, Soc Trang province. Source: Pictures shared by farmer, member of Xom Dong 2 Thoi An Hoi commune, Ke Sach district, Soc Trang province. Date: Aug 31, 2023

Figure 25. Meeting Mr Tran Van Phuong, head of Xom Dong 2 cooperative, Thoi An Hoi commune, Ke Sach district, Soc Trang. Left to right: Lê Thị Như Ý (student in Agricultural Economics, CTU), Trương Thị Ngân (student in Agricultural Economics, CTU), Mr Tran Van Toan (Sub-DARD staff in Ke Sach district, Soc Trang), Mr Tran Van Phuong (head of Xom Dong 2 cooperative), Ms Nguyen Thi Kim Thu (member of the cooperative, who grow Bo Hong milky apple), Chung Thi Ngoc Hue, Nguyen Thi Chuc Ngan (member of the cooperative, who grow Bo Hong milky apple) and Dr Ngo Thi Thanh Truc. Date: Aug, 31, 2023 at Mr. Tran Van Phuong's house, head of Xom Dong 2 cooperative.

Figure 26. The way to Lộc-Mãi cooperative is narrow and slippery after rain (about 1 km from the main road). Date: Sept, 10, 2023 in No. 3 village, Trinh Phú commune, Ke Sach district, Sóc Trăng.

Figure 27. Boats are used to transfer milky apple after sorting and packaging at Lộc Mãi cooperative. Date: Sept 10, 2023 at Lộc Mãi cooperative, No. 3 village, Trinh Phú commune, Kế Sách district, Sóc Trăng.

Figure 28. Visiting the site and member of Loc – Mai cooperative, No. 3 village, Trinh Phu commune, Ke Sach district, Soc Trang province. Left to right: Chung Thi Ngoc Hue, Dr Ngo Thị Thanh Trúc, Nguyen The Kieu Tien (student in Agricultural Economics, CTU), Tran Th Thu Thao (student in Agricultural Economics, CTU), Vo Quoc Viet (member of cooperative), Su Quoc Loc (head of cooperative), Nguyen Thi Nhu Y (student in Agricultural Economics, CTU). Date: Aug 31, 2023

Bao Gia Farm and Danny Green Biomart (part of Hai Au Corp)

Figure 29. Danny Green Biomart, distributed mart/shop selling products of Hai Au Corp, No. 51, 30/4 street, Ninh Kiều district, Can Tho City (22 Oct, 2023).

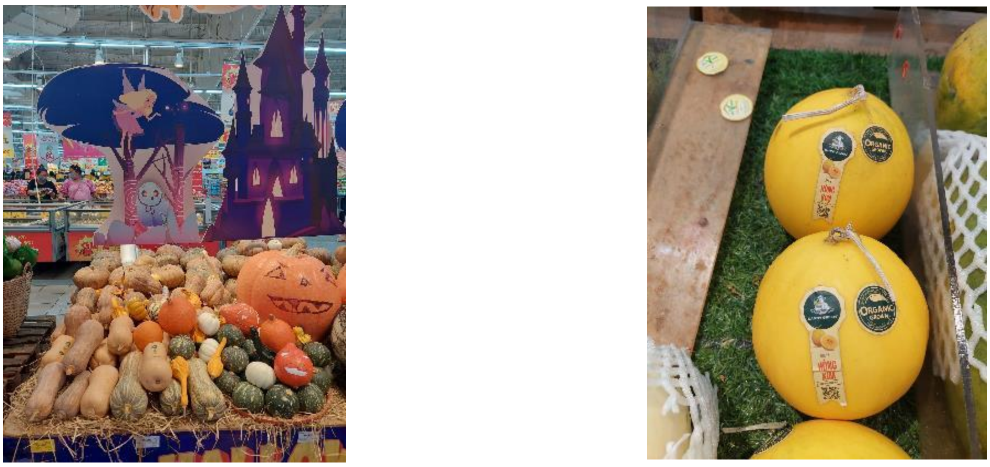

Figure 30. Product of Hai Au corp at Go supermarket, Cai Rang district, Can Tho City

Figure 31. Products of Hai Au Corp, Danny Green Biomart at Can Tho City

Abavina Corp.

Figure 32. Field visit ABAVINA Corp., Phong Điền district, Cần Thơ City. Left to right: Ngô Kim Yến Nhi (student in Natural Resource Economics, CTU), Lê Thị Tuyết Linh (student in Commerce, CTU), Dr Ngô Thị Thanh Trúc, Mrs Nguyễn Thị Kim Thoa (head of ABAVINA), Chung Thị Ngọc Huệ.

Figure 33. Added value products of ABAVINA

Figure 34. Staff of ABAVINA sorting and packaging fresh fruits before delivering to customers. Date: Oct 2, 2023

Figure 35. Field visit Hung Loi cooperative, Long Duc commune, Long Phu district, Soc Trang province. From right to left: Dr Ngo Thi Thanh Truc (School of Economics, CTU), Mr Thanh Tu (technical staff of Hưng Lợi cooperative), Mr Le Van Long (staff of Hưng Lợi cooperative), Mr Vo Van Thanh (staff of Hưng Lợi cooperative), Mr Truong Van Hung (Head of Hung Loi cooperative), Chung Thi Ngoc Hue (School of Economics, CTU), Mr Vo Van Ba (staff of Hung Loi cooperative) and three students in Natural Resource Economics, CTU.

Figure 36. Field visit at Ong Tho milling factory, nearby Hung Loi cooperative, Long Duc commune, Long Phu district, Soc Trang. Left to right: Dr Ngo Thị Thanh Truc, Lam Van Ky (students in Natural Resource Economics, CTU), Mr Truong Van Hung (head of Hung Loi cooperative), Mr Vo Van Thanh (staff of Hung Loi cooperative), Mr Vo Van Ba (staff of Hung Loi cooperative), Mr Thanh Tu (technical staff of Hung Loi cooperative), Nguyen Thi My Duyen (student in Natural Resource Economics, CTU), Tran Thị Thu Thảo (student in Natural Resource Economics, CTU), Chung Thi Ngoc Hue.

10.3.3 Successful factors of market engagement

Leadership

Based on the interviews of six cooperatives, they were established in last five years (2017 – 2021). This was based on central and local orientation to support the development of cooperatives in the whole of Vietnam. However, not many successful cases were listed by the local authorities, such as in Soc Trang, from amongst the hundreds of cooperatives established in the last five years. Most of the heads of the cooperatives were active middlemen, agricultural input suppliers or staff of these communes or villages. For example, the head of the cooperative Tan Trung (green soybean) was formerly a high school teacher and has been an active collector for Antesco for many years. The head of the Loc-Mai cooperative (milky apple) was formally a middleman, and fruit collector in the region.

Getting technical, financial and policy support

Financial and technical support are very important for cooperatives and the other business models. From the policy of cooperatives development, support was received from different projects to build the capacity of the cooperatives, for example the modern community programs (Nong Thon Moi Program), and certification (e.g. VietGAP). These were useful forms of support to new cooperatives to set up their activities. However, many cooperatives could not maintain or become self-sufficient in their activities when the supporting project ended. The technical support through training was also difficult to continue to disseminate or transfer the technical support once these projects ended. In some cases, local farmers preferred to grow and market their produce independently.

High demand from the market

Milky apple in the two cooperatives in Soc Trang is a good example that helps to make these two cooperatives successful. This fruit has high demand for export to Asian communities in the US. However, this fruit has also not been successfully grown in Thailand and in other regions of Vietnam. According to the local communities in Ke Sach, Soc Trang, this fruit grows quite well there but the quality is not as good as when they are grown in other provinces such as Can Tho, Tien Giang or Ben Tre.

Reduce market risks

Farmers, groups of farmers and cooperatives have chosen to collaborate with the enterprises in selling their farm products to reduce market risks such as fluctuations in selling price, and making it possible for companies to buy big quantities from farms (green soybean, baby corn, milky apple and rice). For example, farmers who grow more than 0.2 ha of soybean expect to sell their products to the enterprises rather than to middlemen. However, selling products to enterprises might result in a lower price than selling products to the middlemen.

10.3.4 Constraints in markets engagement and upscaling

Low market demand

Even milky apple can be exported by Loc Mai cooperatives. They can only export to T&T and Anh Duong Sao about 10 - 30% of products in this commune. Thus, relying on only 1-2 enterprises in consuming their products is very risky and there is small demand for the products.

Upscaling the business model

ABAVINA is a good business model in gathering farmers, though they still maintain at very small scale. It is very difficult for them to expand their business as well as to increase the number of farmer communities due to lack of resources. In the case of ABAVINA, there was a lack of human resources to expand their business and activities. They also lacked financial market research support.

Small scale of business

In many cases the local authorities and cooperatives replied mostly from single companies such as Ong Tho Corp. (Tan Hung Cooperative), Antesco (Tan Trung and Hoi An Cooperative), T&T and Anh Duong Sao (Loc Mai and Xom Dong 2 cooperative). However, these companies cannot buy products of the whole commune or district. Thus, they bought only a proportion of the products from their cooperative members. The cooperatives do not have strong capacity to find new buyers. Expansion of production area, for example for green soybean and baby corn, has increased very fast. The same situation of milky apple in Xom Dong 2 cooperative might happen in the next few years. In the case of Antesco, they have less customers after COVID, pushed them to restrict the quantity of green soybean and baby corn buying from their collecting agents or cooperatives.

Small scale farming

Small scale farming is associated with difficulties in gathering big volumes of products with uniform and quality required from big buyers or exporters. It has created low efficiency from small scale farming. Learning from this problem, Hai Au Corp. chose to invest by themselves in upscaling farming activities to market the product in high price channels such as their own private shops (e.g. Danny Green), supermarkets (e.g. Go, Vinmart, Lotte) and plans to export. This strategy might not bring benefits to the public; however, it is a good routine that FOCUS may consider disseminating their outputs.

Contracting schemes

In the case of rice contracting, farmers have not accepted long term contracts or make contracts at the beginning of the paddy crop. Both the suppliers and buyers only made the price decision in 20 days before harvest. This contract scheme showed that they do not trust each other. Even farmers complained about their difficulties and consuming their products, they have not been willing to implement contracting for their farms.

From single company buying products from cooperatives, these companies have more power in price decisions (monopoly). Thus, the scheme of market engagement in the case of cooperatives of rice, green soybean and baby corn generated a big processing companies and small farmers or new cooperatives. The cooperatives do have a strong voice to bargain or negotiate price and payment terms to these companies.

Fear of making a loss

The cooperatives and the enterprises and small farmers have to build enough trust; thus both the buyers and sellers have not been willing to make contracts from the beginning of the crop or to make long-term contracts. It happens in rice, soybean and baby corn. Besides, sorting the products before selling might generate more return for farmers. However, they have not become used to this practice and fear receiving a lower return if sorting their farm products. The fear of loss and to try new things also arise from the failure of the previous programs in business engagement.

10.4 Conclusions

This report presents preliminary findings from the six cases. Even though they are listed as the best practice of enterprise engagement in the VMD, the scale of business is still small and weak in their operation. These upland cases are quite unique when the market engagement and collaboration in upland crops has not been popular comparing to the rice cases. They have been experiencing either progress or degradation in their business. However, these three business models are good examples for us to learn and understand which type of these business model FOCUS or other research should make use of to disseminate their new crops or technologies to the society in the private sector or in terms of market engagement.

The factors that lead to successful market engagement included effective leadership of the heads of cooperatives or enterprises. This is one of the most important factors that maintains market-oriented production in all six cases. The demand of the products is the core factor that leads to sustainable linkages between the output enterprises and cooperatives, enterprises or groups of farmers. Support from the government to promote cooperative development, start up and innovation gives opportunities for these cases.

Besides the successful factors, there still have several constraints in the development of the private and market engagement. These include low market demand for the products, the small scale of both businesses and farming practices, and possible restrictions on the possibilities of upscaling these three business models. Other factors include details in contracting schemes, and fear of loss. Further analysis will go deeper into each case, to understand the relationship among stakeholders that leads to the success or constraint in their business.

The information arising from this research will help in the design of contracts which optimise benefits for both parties. This will also help improve vertical coordination in the supply chain of upland crops in the VMD in particular and in Vietnam in general. Local government will need to provide some support, such as the establishment of cooperatives, witnessing the signature of contracts between the two parties, and organising meetings with related parties to solve difficulties in the contract performance process (if any) to protect the benefits of both parties.

Advantages of transformative adaptation may include: alternative crops may provide farmers with the opportunity to increase their business profitability; diversification may help insulate farmers from price and demand fluctuations in the marketplace for agricultural commodities; there is potential to further improve the role that women and youth play in production of upland crops; policy implementation may be improved to minimise production barriers and facilitate private sector engagement in the honeydew melon and baby corn value chains.

Some issues may need to be addressed to ensure successful transformative adaptation: markets for upland crop alternatives must be viable, with a mature value chain underpinning successful ongoing profitability; change to an alternative crop is likely to require considerable up-front investment and potentially higher ongoing inputs; farmers require training and skills development in crops that they have less familiarity with from government and private providers; farmers need stronger links and relationships with buyer companies, with government potentially acting as a bridge between these value chain actors.

Integrating smallholder farming families effectively with markets at local to international scales can deliver benefits including enhanced on-farm resource use efficiency, increasing returns to scale, reduced per-unit costs of production, and greater focus on productivity/profitable agriculture rather than subsistence agriculture. Farmers are more likely to seek participation in markets when they perceive that these benefits of doing so will outweigh the costs (Wickramasinghe et al. 2014).

Improvement in marketing (access, procedures and capacity) was revealed as a key need for novel crops by this research. Novel crops are worthy of consideration as sustainable alternatives to rice from the agronomic perspective, *but they require a valid market and accessible value chain in order for farmers to be willing to change their system to produce the new crop*. Ideally, these crops will be at least as profitable, or more profitable, than rice.

Further research is needed regarding market engagement, farmer business upskilling, value chain development, supporting startups and new business opportunities. These initiatives should incorporate Gender Equality, Disability, and Social Inclusion (GEDSI) principles, with a focus on women, youth and ethnic minorities (i.e. Khmer communities).

References

Ackerl, T., Weldemariam, L.F., Nyasimi, M. and Ayanlade, A. 2023. Climate change risk, resilience, and adaptation among rural farmers in East Africa: A literature review. *Regional Sustainability.* 4(2): 185-193. 10.1016/j.regsus.2023.05.004.

Ahearn, M.C., Liang, K. and Goetz, S. 2018. Farm business financial performance in local foods value chains. *Agricultural Finance Review.* 78(4): 470-488. 10.1108/AFR-08-2017-0071.

Ahmad, W. and Anders, S. 2012. The Value of Brand and Convenience Attributes in Highly Processed Food Products. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie.* 60(1): 113-133. 10.1111/j.1744-7976.2011.01234.x.

Alam, M.J., Humphreys, E., Sarkar, M.A.R. and Sudhir, Y. 2017. Intensification and diversification increase land and water productivity and profitability of rice-based cropping systems on the High Ganges River Floodplain of Bangladesh. *Field Crops Research.* 209: 10-26. 10.1016/j.fcr.2017.04.008.

Alvarez, S., Paas, W., Descheemaeker, K., Tittonell, P. and Groot, J. 2014. *Constructing Typologies, a Way to Deal with Farm Diversity: General Guidelines for the Humidtropics*. Plant Sciences Group, Wageningen University, Wageningen.

Alvarez, S., Timler, C.J., Michalscheck, M., Paas, W., Descheemaeker, K., Tittonell, P., Andersson, J.A. and Groot, J.C.J. 2018. Capturing farm diversity with hypothesis-based typologies: An innovative methodological framework for farming system typology development. *PLOS ONE.* 13(5): e0194757. 10.1371/journal.pone.0194757.

Ammar, E.E. 2022. Crop diversification in the Egyptian Nile Region; viewpoint of spatial, climatic, and human features. *Saudi Journal of Biological Sciences.* 29(12): 103451. 10.1016/j.sjbs.2022.103451.

Anang, B.T. and Apedo, C.K. 2023. The influence of off-farm work on farm income among smallholder farm households in northern Ghana. *Cogent Economics & Finance.* 11(1): 2196861. 10.1080/23322039.2023.2196861.

Andreyeva, T., Long, M.W. and Brownell, K.D. 2010. The Impact of Food Prices on Consumption: A Systematic Review of Research on the Price Elasticity of Demand for Food. *American journal of public health.* 100(2): 216-222. 10.2105/AJPH.2008.151415.

Arifin, B., Nuryartono, D.N., Pasaribu, S.H., Yasmin, F., Rifai, M.A. and Kurniadi, R. 2019. *Profitability and Labor Productivity in Indonesian Agriculture*. World Bank Group, Washington, D.C. .

Aryal, J.P., Sapkota, T.B., Khurana, R., Khatri-Chhetri, A., Rahut, D.B. and Jat, M.L. 2020. Climate change and agriculture in South Asia: adaptation options in smallholder production systems. *Environment, Development and Sustainability.* 22(6): 5045-5075. 10.1007/s10668-019-00414-4.

Asfaw, A. and Admassie, A. 2004. The role of education on the adoption of chemical fertiliser under different socioeconomic environments in Ethiopia. *Agricultural Economics.* 30(3): 215-228. 10.1016/j.agecon.2002.12.002.

Assefa, T.T., Meuwissen, M.P.M. and Oude Lansink, A.G.J.M. 2015. Price Volatility Transmission in Food Supply Chains: A Literature Review. *Agribusiness.* 31(1): 3-13. 10.1002/agr.21380.

Awoke Eshetae, M., Abera, W., Tamene, L., Mulatu, K. and Tesfaye, A. 2024. Understanding farm typology for targeting agricultural development in mixed crop-livestock farming systems of Ethiopia. *Farming System.* 2(3): 100088. 10.1016/j.farsys.2024.100088.

Bartkowski, B., Schüßler, C. and Müller, B. 2022. Typologies of European farmers: approaches, methods and research gaps. *Regional Environmental Change.* 22(2): 43. 10.1007/s10113-022-01899-y.

Bâtie, C., Ha, L.T.T., Loire, E., Truong, D.B., Tuan, H.M., Cuc, N.T.K., Paul, M. and Goutard, F. 2022. Characterisation of chicken farms in Vietnam: A typology of antimicrobial use among different production systems. *Preventive Veterinary Medicine.* 208: 105731. 10.1016/j.prevetmed.2022.105731.

Bedeke, S., Vanhove, W., Gezahegn, M., Natarajan, K. and Van Damme, P. 2019. Adoption of climate change adaptation strategies by maize-dependent smallholders in Ethiopia. *NJAS: Wageningen Journal of Life Sciences.* 88(1): 96-104. 10.1016/j.njas.2018.09.001.

Bernzen, A., Sohns, F., Jia, Y. and Braun, B. 2023. Crop diversification as a household livelihood strategy under environmental stress. Factors contributing to the adoption of crop diversification in shrimp cultivation and agricultural crop farming zones of coastal Bangladesh. *Land Use Policy.* 132: 106796. 10.1016/j.landusepol.2023.106796.

Betcherman, G., Haque, I. and Marschke, M. 2021. Exploring livelihood transitions in the Mekong delta. *Singapore Journal of Tropical Geography.* 42(2): 222-240. 10.1111/sjtg.12300.

Bhullar, A., Nadeem, K. and Ali, R.A. 2023. Simultaneous multi-crop land suitability prediction from remote sensing data using semi-supervised learning. *Scientific Reports.* 13(1): 6823. 10.1038/s41598-023-33840-6.

Bidogeza, J.C., Berentsen, P.B.M., De Graaff, J. and Oude Lansink, A.G.J.M. 2009. A typology of farm households for the Umutara Province in Rwanda. *Food security.* 1(3): 321-335. 10.1007/s12571-009-0029-8.

Blanc, E., Lepine, A. and Strobl, E. 2016. Determinants of crop yield and profit of family farms: Evidence from the Senegal river valley. *Experimental Agriculture.* 52(1): 110-136. 10.1017/S0014479714000581.

Borelli, S., Wangpakapattanawong, P., Oborn, I., Roshethko, J., Shono, K. and Hillbrand, A. 2017. *Agroforestry in rice-production landscapes in South-East Asia: a practical manual*.

Bousbia, A., Gueroui, Y., Aouadi, A., Teweldebirhan, M.D., Bessa, R.J.B., Symeon, G. and Boudalia, S. 2024. Typology analysis of cattle farms in Northeast Algeria: Potential for sustainable development. *Agricultural Systems.* 218: 103995. 10.1016/j.agsy.2024.103995.

Branca, G., Arslan, A., Paolantonio, A., Cavatassi, R., McCarthy, N., VanLinh, N. and Lipper, L. 2018. Economic Analysis of Improved Smallholder Paddy and Maize Production in Northern Viet Nam and Implications for Climate-Smart Agriculture. In: Lipper, L., McCarthy, N., Zilberman, D., Asfaw, S. and Branca, G. (eds.) *Climate Smart Agriculture: Building Resilience to Climate Change*. Springer International Publishing, Cham. pp. 563-595.

Brodt, S., Klonsky, K. and Tourte, L. 2006. Farmer goals and management styles: Implications for advancing biologically based agriculture. *Agricultural Systems.* 89(1): 90-105. 10.1016/j.agsy.2005.08.005.

Bryan, E., Deressa, T.T., Gbetibouo, G.A. and Ringler, C. 2009. Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environmental Science & Policy.* 12(4): 413-426. https://doi.org/10.1016/j.envsci.2008.11.002.

CCAFS-SEA. 2016. *Assessment Report: The drought and salinity intrusion in the Mekong River Delta of Vietnam*. CGIAR, Hanoi.

Coe, C.A. 2016. The allocation of household-based forest protection contracts in Tam Dao National Park, Vietnam: Elite capture as a bureaucratic impulse against community capture. *Journal of Sustainable Forestry.* 35(2): 89-118. 10.1080/10549811.2015.1101700.

Dam, T.H.T., Tur-Cardona, J., Speelman, S., Amjath-Babu, T.S., Sam, A.S. and Zander, P. 2021. Incremental and transformative adaptation preferences of rice farmers against increasing soil salinity - Evidence from choice experiments in north central Vietnam. *Agricultural Systems.* 190: 103090. 10.1016/j.agsy.2021.103090.

Daxini, A., Ryan, M., Odonoghue, C., Barnes, A. and Buckley, C. 2019. Using a typology to understand farmers' intentions towards following a nutrient management plan. *Resources Conservation and Recycling.* 146: 280-290. 10.1016/j.resconrec.2019.03.027.

De Janvry, A. and Sadoulet, E. 2019a *Transforming Developing Country Agriculture: Removing Adoption Constraints and Promoting Inclusive Value Chain Development*.

de Janvry, A. and Sadoulet, E. 2019b. *Transforming Developing Country Agriculture: Removing Adoption Constraints and Promoting Inclusive Value Chain Development (Working Paper)*. Foundation for Studies and Research on International Development, Clermont-Ferrand.

de Roest, K., Ferrari, P. and Knickel, K. 2018. Specialisation and economies of scale or diversification and economies of scope? Assessing different agricultural development pathways. *Journal of Rural Studies.* 59: 222-231. https://doi.org/10.1016/j.jrurstud.2017.04.013.

Demont, M. and Rutsaert, P. 2017. Restructuring the Vietnamese rice sector: towards increasing sustainability. *Sustainability.* 9(2): 325. 10.3390/su9020325.

Dendir, Z. and Simane, B. 2021. Farmers’ perceptions about changes in climate variables: Perceived risks and household responses in different agro-ecological communities, Southern Ethiopia. *Climate Services.* 22: 100236. https://doi.org/10.1016/j.cliser.2021.100236.

Dethier, J.-J. and Effenberger, A. 2012. Agriculture and development: A brief review of the literature. *Economic Systems.* 36(2): 175-205. 10.1016/j.ecosys.2011.09.003.

Devkota, K.P., Pasuquin, E., Elmido-Mabilangan, A., Dikitanan, R., Singleton, G.R., Stuart, A.M., Vithoonjit, D., Vidiyangkura, L., Pustika, A.B., Afriani, R., Listyowati, C.L., Keerthisena, R.S.K., Kieu, N.T., Malabayabas, A.J., Hu, R., Pan, J. and Beebout, S.E.J. 2019. Economic and environmental indicators of sustainable rice cultivation: A comparison across intensive irrigated rice cropping systems in six Asian countries. *Ecological Indicators.* 105: 199-214. 10.1016/j.ecolind.2019.05.029.

Devkota, M. and Yigezu, Y.A. 2020. Explaining yield and gross margin gaps for sustainable intensification of the wheat-based systems in a Mediterranean climate. *Agricultural Systems.* 185: 102946. 10.1016/j.agsy.2020.102946.

Dey, M.M. and Prein, M. 2005. Increased Income from Seasonally Flooded Rice Fields through Community Based Fish Culture in Bangladesh and Vietnam. *Plant Production Science.* 8(3): 349-353. 10.1626/pps.8.349.

Directorate Marketing. 2021. *A Profile of the South African Beetroot Market Value Chain 2021* Department of Agriculture, Land Reform and Rural Development, Pretoria.

Do, H. 2022. *6 months: Export turnover of agricultural, forestry, and fishery products increased by nearly 14%*. Government News. 28 June. https://baochinhphu.vn/6-thang-kim-ngach-xuat-khau-nong-lam-thuy-san-tang-gan-14-102220628164627465.htm.

Duc Tran, D., Park, E., Tran, T.A., Vo, T.T. and Le, P.T. 2023. Socio-hydrological trade-offs arising from triple cropping in the Vietnamese Mekong Delta: Revisiting environmental impacts and adaptation pathways. *Environmental Technology & Innovation.* 29: 102987. 10.1016/j.eti.2022.102987.

Duc Tran, D., Thi Bich Thuc, P., Park, E., Thi Thanh Hang, P., Ba Man, D. and Wang, J. 2024. Extent of saltwater intrusion and freshwater exploitability in the coastal Vietnamese Mekong Delta assessed by gauging records and numerical simulations. *Journal of Hydrology.* 630: 130655. 10.1016/j.jhydrol.2024.130655.

Duffy, M. 2009. Economies of Size in Production Agriculture. *Journal of Hunger & Environmental Nutrition.* 4(3-4): 375-392. 10.1080/19320240903321292.

Esri. 2022. *ArcGIS Pro Version 3.0*. Esri, Redlands.

Fan, S. and Rue, C. 2020. The Role of Smallholder Farms in a Changing World. In: Gomez y Paloma, S., Riesgo, L. and Louhichi, K. (eds.) *The Role of Smallholder Farms in Food and Nutrition Security*. Springer International Publishing, Cham. pp. 13-28.

Fedele, G., Donatti, C.I., Harvey, C.A., Hannah, L. and Hole, D.G. 2019. Transformative adaptation to climate change for sustainable social-ecological systems. *Environmental Science and Policy.* 101: 116-125. 10.1016/j.envsci.2019.07.001.

Galloway, A. 2005. Non-Probability Sampling. In: Kempf-Leonard, K. (ed.) *Encyclopedia of Social Measurement*. Elsevier, New York. pp. 859-864.

Gathala, M.K., Timsina, J., Islam, M.S., Rahman, M.M., Hossain, M.I., Harun-Ar-Rashid, M., Ghosh, A.K., Krupnik, T.J., Tiwari, T.P. and McDonald, A. 2015. Conservation agriculture based tillage and crop establishment options can maintain farmers' yields and increase profits in South Asia's rice–maize systems: Evidence from Bangladesh. *Field Crops Research.* 172: 85-98. 10.1016/j.fcr.2014.12.003.

Gong, Y., Li, H., Parks, M., Pang, J. and de Fraiture, C. 2018. The role of social capital for farmers' climate change adaptation in Lancang River basin in China. *Climate Change.* 149: 75-89.

Gonsalves, J., Carandang, A., Verallo III, J.R. and Barbon, W.J. 2022. Derisking delta-oriented value chains in Cambodia, Vietnam and Myanmar: Scoping study on key production systems and value chains.

GoV. 2017. *Resolution 120 on Sustainable and Climate-Resilient Development of the Mekong River Delta*. Government of Vietnam, Hanoi.

GoV. 2021. *Decision 255 on Approval of Agricultural Restructure Plan for the 2021-2025 Period*. Government of Vietnam, Hanoi.

Government of Viet Nam. 2021. *Prime Minister's Decision No.255 dated 25 February 2021 approving the Master Plan for Agricultural Restructuring for 2021–2025*.

Government of Vietnam. 2021. *Decision 255 on Approval of Agricultural Restructure Plan for the 2021-2025 Period*. Government of Vietnam, Hanoi.

GSO. 2021. *Statistical yearbook of Viet Nam 2020*.

Hansen, A. 2018. Meat consumption and capitalist development: The meatification of food provision and practice in Vietnam. *Geoforum.* 93: 57-68. 10.1016/j.geoforum.2018.05.008.

Haryanto, T., Wardana, W.W., Jamil, I.R., Brintanti, A.R.D. and Ibrahim, K.H. 2023. Impact of credit access on farm performance: Does source of credit matter? *Heliyon.* 9(9): e19720. 10.1016/j.heliyon.2023.e19720.

Ho, T.D.N., Tsusaka, T.W., Kuwornu, J.K.M., Datta, A. and Nguyen, L.T. 2021. Do rice varieties matter? Climate change adaptation and livelihood diversification among rural smallholder households in the Mekong Delta region of Vietnam. *Mitigation and Adaptation Strategies for Global Change.* 27(1): 8. 10.1007/s11027-021-09978-x.

Hoan, N.X., Nguyen Khoi, D. and Trung, L.D. 2019. Assessing the adaptive capacity of farmers under the impact of saltwater intrusion in the Vietnamese Mekong Delta. *Journal of Environmental Planning and Management.* 62(9): 1619-1635. 10.1080/09640568.2019.1631147.

Hoang, L.P., van Vliet, M.T.H., Kummu, M., Lauri, H., Koponen, J., Supit, I., Leemans, R., Kabat, P. and Ludwig, F. 2019. The Mekong's future flows under multiple drivers: How climate change, hydropower developments and irrigation expansions drive hydrological changes. *Science of The Total Environment.* 649: 601-609. 10.1016/j.scitotenv.2018.08.160.

Hoang, V. and Nguyen, V. 2023. Determinants of small farmers' participation in contract farming in developing countries: A study in Vietnam. *Agribusiness.* 39(3): 836-853.

Horgan, F.G., Mundaca, E.A., Hadi, B.A.R. and Crisol-Martínez, E. 2023. Diversified rice farms with vegetable plots and flower strips are associated with fewer pesticide applications in the Pshilippines. *Insects.* 14(10). 10.3390/insects14100778.

Howden, S.M., Soussana, J.-F., Tubiello, F.N., Chhetri, N., Dunlop, M. and Meinke, H. 2007. Adapting agriculture to climate change. *Proceedings of the National Academy of Sciences.* 104(50): 19691-19696. doi:10.1073/pnas.0701890104.

Hua, H.H. and Brown, P.R. 2024. Social capital enhances the resilience of agricultural cooperatives: comparative case studies in the Mekong Delta, Vietnam. *World Development Sustainability.* 100170.

Huber, R., Bartkowski, B., Brown, C., El Benni, N., Feil, J.-H., Grohmann, P., Joormann, I., Leonhardt, H., Mitter, H. and Müller, B. 2024. Farm typologies for understanding farm systems and improving agricultural policy. *Agricultural Systems.* 213: 103800. https://doi.org/10.1016/j.agsy.2023.103800.

Huka, H., Ruoja, C. and Mchopa, A. 2014. Price fluctuation of agricultural products and its impact on small scale farmers development: Case analysis from Kilimanjaro Tanzania. *European Journal of Business and Management.* 6(36): 155-160.

Huong, N.V. and Yorobe, J.M. 2017. Maize supply response in Vietnam. *Asian Journal of Agriculture and Development.* 14(1): 89-105.

Huong, P.T.T., Everaarts, A.P., Neeteson, J.J. and Struik, P.C. 2013a. Vegetable production in the Red River Delta of Vietnam. I. Opportunities and constraints. *NJAS: Wageningen Journal of Life Sciences.* 67(1): 27-36. 10.1016/j.njas.2013.09.002.

Huong, P.T.T., Everaarts, A.P., Neeteson, J.J. and Struik, P.C. 2013b. Vegetable production in the Red River Delta of Vietnam. II. Profitability, labour requirement and pesticide use. *NJAS: Wageningen Journal of Life Sciences.* 67(1): 37-46. 10.1016/j.njas.2013.09.003.

Huong, P.T.T., Everaarts, A.P., Neeteson, J.J. and Struik, P.C. 2019. Performance of Permanent Vegetable Production Systems Designed with the PermVeg Model for the Red River Delta, Vietnam. *Sustainability.* 11(10). 10.3390/su11102719.

Huong, P.T.T., Everaarts, A.P., van den Berg, W., Neeteson, J.J. and Struik, P.C. 2014. Permveg: A model to design crop sequences for permanent vegetable production systems in the Red River Delta, Vietnam. *Journal of Agronomy and Crop Science.* 200(4): 302-316. 10.1111/jac.12074.

Huynh, L.T.M. and Stringer, L.C. 2018. Multi-scale assessment of social vulnerability to climate change: An empirical study in coastal Vietnam. *Climate Risk Management.* 20: 165-180.

Huỳnh, T. 2025. *Công ty Antesco và xã Mỹ An ký kết đề án sản xuất bắp thu trái non (Antesco Company and My An Commune signed a project to produce young corn)*. Antesco, Long Xuyen. https://antesco.com/vi/cong-ty-antesco-va-xa-my-an-ky-ket-de-an-san-xuat-bap-thu-trai-non/.

IBM Corp. 2023. *SPSS Statistics Version 29*. International Business Machines Corporation.

IMF, O. and UNCTAD, W. 2011. Price volatility in food and agricultural markets: Policy responses. *FAO: Roma, Italy.*

Islam, S., Mazariegos, V., Nagarajan, G. and Zaman, L. 2015. Effects of farmer cooperatives on expanding agricultural markets in developing countries: a systematic review. *US Department of Agriculture.*

Jamal, M.R., Kristiansen, P., Kabir, M.J. and Lobry de Bruyn, L. 2022. Cropping systems intensification and diversification: risk, vulnerability and adaptation in southwest coastal Bangladesh. *International Journal of Sustainable Development & World Ecology.* 29(8): 677-694. 10.1080/13504509.2022.2073615.

Jansen, H.G.P., Midmore, D.J., Binh, P.T., Valasayya, S. and Tru, L.C. 1996. Profitability and sustainability of peri-urban vegetable production systems in Vietnam. *Netherlands Journal of Agricultural Science.* 44: 125-143.

Jiang, Z., Raghavan, S.V., Hur, J., Sun, Y., Liong, S.Y., Nguyen, V.Q. and Van Pham Dang, T. 2019. Future changes in rice yields over the Mekong River Delta due to climate change—Alarming or alerting? *Theoretical and Applied Climatology.* 137(1-2): 545-555. 10.1007/s00704-018-2617-z.

Joffre, O.M. and Bosma, R.H. 2009. Typology of shrimp farming in Bac Lieu Province, Mekong Delta, using multivariate statistics. *Agriculture, Ecosystems & Environment.* 132(1): 153-159. 10.1016/j.agee.2009.03.010.

Josse, J. and Husson, F. 2016. missMDA: A package for handling missing values in multivariate data analysis. *Journal of Statistical Software.* 70(1): 1-31. 10.18637/jss.v070.i01.

Kabir, M.J., Alauddin, M. and Crimp, S. 2017. Farm-level adaptation to climate change in Western Bangladesh: An analysis of adaptation dynamics, profitability and risks. *Land Use Policy.* 64: 212-224. 10.1016/j.landusepol.2017.02.026.

Kassambara, A. 2017. *Practical Guide to Principal Component Methods in R*. Sthda.com, Online.

Kassambara, A. and Mundt, F. 2020. *factoextra: Extract and Visualize the Results of Multivariate Data Analyses*. DataNovia, Sydney. https://CRAN.R-project.org/package=factoextra.

Kaveney, B., Barrett-Lennard, E., Chau Minh, K., Dang Duy, M., Nguyen Thi, K.P., Kristiansen, P., Orgill, S., Stewart-Koster, B. and Condon, J. 2023. Inland dry season saline intrusion in the Vietnamese Mekong River Delta is driving the identification and implementation of alternative crops to rice. *Agricultural Systems.* 207: 103632. 10.1016/j.agsy.2023.103632.

Khoi, P.D., Gan, C., Nartea, G.V. and Cohen, D.A. 2013. Formal and informal rural credit in the Mekong River Delta of Vietnam: Interaction and accessibility. *Journal of Asian Economics.* 26: 1-13. 10.1016/j.asieco.2013.02.003.

Kiger, M.E. and Varpio, L. 2020. Thematic analysis of qualitative data: AMEE Guide No. 131. *Medical Teacher.* 42(8): 846-854. 10.1080/0142159X.2020.1755030.

Kim, H.-J. 2016. Opportunities and Challenges of Alternative Specialty Crops: The Global Picture. *HortScience.* 51(11): 1316-1319. 10.21273/hortsci10659-16.

Kimura, F. 2023. *Viet Nam 2045: Development Issues and Challenges*. Economic Research Institute for ASEAN and East Asia (ERIA).

Kirkden, R., Edwards, J. and Broom, D. 2003. A theoretical comparison of the consumer surplus and the elasticities of demand as measures of motivational strength. *Animal Behaviour.* 65(1): 157-178.

Kobo. 2024. *KoboToolbox*. Kobo, Cambridge, Massachusetts. https://www.kobotoolbox.org/.

Lavane, K., Kumar, P., Meraj, G., Han, T.G., Ngan, L.H.B., Lien, B.T.B., Van Ty, T., Thanh, N.T., Downes, N.K., Nam, N.D.G., Minh, H.V.T., Singh, S.K. and Kanga, S. 2023. Assessing the Effects of Drought on Rice Yields in the Mekong Delta. *Climate.* 11(1): 13.

Le, S., Julie, J. and Husso, F. 2008. FactoMineR: An R package for multivariate analysis. *Journal of Statistical Software.*(25(1)): 1-18. 10.18637/jss.v025.i01.

Le, S.T., Mao, N.H., Kristiansen, P. and Coleman, M. 2025. Innovation in two contrasting value chains: Constraints and opportunities for adopting alternative crop production in the Vietnamese Mekong River Delta. *Regional Sustainability.* 6(1): 100198. 10.1016/j.regsus.2025.100198.

Le, S.T. and Vo, C.D. 2021. The livelihood adaptability of households under the impact of climate change in the Mekong Delta. *Journal of Agribusiness in Developing and Emerging Economies.* 11(1): 7-26. 10.1108/JADEE-09-2019-0139.

Le, T.H.L., Dang, K.K., Moss, J., Nguyen, H.Q. and Kristiansen, P. 2024a. Chapter 17 - Agricultural transformation in the Vietnamese Mekong Delta in the new era. In: Nguyen, H.Q., Apel, H., Le, Q.B., Nguyễn, M.T. and Sridhar, V. (eds.) *The Mekong River Basin*. Elsevier. pp. 559-617.

Le, T.H.L., Kristiansen, P., Vo, B., Moss, J. and Welch, M. 2024b. Understanding factors influencing farmers' crop choice and agricultural transformation in the Upper Vietnamese Mekong Delta. *Agricultural Systems.* 216: 103899. https://doi.org/10.1016/j.agsy.2024.103899.

Le, T.N., Bregt, A.K., van Halsema, G.E., Hellegers, P.J.G.J. and Ngo, T.T. 2023a *Multi-Scale Drivers of Land-Use Changes at Farm Level I: Conceptual Framework and Application in the Highly Flooded Zone of the Vietnamese Mekong Delta*.

Le, T.T., Pham, T.K.D., Tuan, M.L., Giles, J. and Swaans, C. 2023b. Climate Risk & Vulnerability (CR&V) assessment for climate services: fruit production and value chain-Mekong River Delta, Viet Nam.

Le, T.T.D. 2020 *Agricultural Extension System in Vietnam and Its Development: Comparative Studies in Thailand and Philippines*. Ritsumeikan Asia Pacific University, Oita.

Lin, B. 2011. Resilience in agriculture through crop diversification: Adaptive management for environmental change. *BioScience.* 61: 183-193. 10.1525/bio.2011.61.3.4.

Lin, C.-T.J., Jensen, K.L. and Yen, S.T. 2005. Awareness of foodborne pathogens among US consumers. *Food Quality and Preference.* 16(5): 401-412. https://doi.org/10.1016/j.foodqual.2004.07.001.

Liu, T., Bruins, R.J.F. and Heberling, M.T. 2018. Factors Influencing Farmers' Adoption of Best Management Practices: A Review and Synthesis. *Sustainability.* 10(2): 432.

Liu, Y., Barrett, C.B., Pham, T. and Violette, W. 2020. The intertemporal evolution of agriculture and labor over a rapid structural transformation: Lessons from Vietnam. *Food Policy.* 94: 101913. https://doi.org/10.1016/j.foodpol.2020.101913.

Loc, H.H., Low Lixian, M., Park, E., Dung, T.D., Shrestha, S. and Yoon, Y.-J. 2021a. How the saline water intrusion has reshaped the agricultural landscape of the Vietnamese Mekong Delta, a review. *Science of The Total Environment.* 794: 148651. https://doi.org/10.1016/j.scitotenv.2021.148651.

Loc, H.H., Van Binh, D., Park, E., Shrestha, S., Dung, T.D., Son, V.H., Truc, N.H.T., Mai, N.P. and Seijger, C. 2021b. Intensifying saline water intrusion and drought in the Mekong Delta: From physical evidence to policy outlooks. *Science of The Total Environment.* 757: 143919. https://doi.org/10.1016/j.scitotenv.2020.143919.

Ma, W., Rahut, D.B., Sonobe, T. and Gong, B. 2024. Linking farmers to markets: Barriers, solutions, and policy options. *Economic Analysis and Policy.* 82: 1102-1112. https://doi.org/10.1016/j.eap.2024.05.005.

Mackay, P. and Russell, M. 2011. *Socialist Republic of Viet Nam: Climate Change Impact and Adaptation Study in the Mekong Delta*. Asian Development Bank.

MARD. 2023. *Decision 470 about Promulgating the plan to change cropping patterns on rice land nationwide in 2023*.

Martins, I.M. and Gasalla, M.A. 2020. Adaptive Capacity Level Shapes Social Vulnerability to Climate Change of Fishing Communities in the South Brazil Bight. *Frontiers in Marine Science.* 7(481). 10.3389/fmars.2020.00481.

Masuku, M. and Xaba, B. 2013. Factors affecting the productivity and profitability of vegetables production in Swaziland. *Journal of Agricultural Studies.* 1. 10.5296/jas.v1i2.3748.

Mekonnen, D.K., Yimam, S., Arega, T., Matheswaran, K. and Schmitter, P.M.V. 2022. Relatives, neighbors, or friends: Information exchanges among irrigators on new on-farm water management tools. *Agricultural Systems.* 203: 103492. https://doi.org/10.1016/j.agsy.2022.103492.

Melas, K.D., Faitatzoglou, A., Michail, N.A. and Artemiou, A. 2024. Volatility Spillovers among the Major Commodities: A Review. *Journal of Risk and Financial Management.* 17(8): 365.

Mergenthaler, M., Weinberger, K. and Qaim, M. 2009. The food system transformation in developing countries: A disaggregate demand analysis for fruits and vegetables in Vietnam. *Food Policy.* 34(5): 426-436. 10.1016/j.foodpol.2009.03.009.

Microsoft. 2019. *Microsoft Excel Version 16 for Mac*. Microsoft Corporation, Redmond.

Mills, B., Phuong, L.D., Phuc, T.D., Lien, N., Thanh, V.D. and and Labarta, R. 2023. Intensive and extensive rice farm adaptations in salinity-prone areas of the Mekong Delta. *Climate and Development.* 15(2): 162-176. 10.1080/17565529.2022.2072800.

Mills, B., Ta, C., Ta, D.P. and Nguyen, H. 2025. Salinity inundation, profitability, and rice farming exits in the Mekong Delta of Vietnam. *Journal of the Agricultural and Applied Economics Association.* n/a(n/a). 10.1002/jaa2.70004.

Ministry of Natural Resources and Environment and al., e. 2013. *Mekong Delta Plan: Long-term vision and strategy for a safe, prosperous and sustainable delta*. Ministry of Natural Resources and Environment et al.

Mishra, A., Wilson, C. and Williams, R. 2009. Factors affecting financial performance of new and beginning farmers. *Agricultural Finance Review.* 69(2): 160-179. 10.1108/00021460910978661.

Moran, J. 2009. Measures of Farm Profit. In: *Business Management for Tropical Dairy Farmers*. Landlinks Press, Victoria. p. 297.

Mussa, R. 2015. The effects of educational externalities on maize production in rural Malawi. *Oxford Development Studies.* 43(4): 508-532. 10.1080/13600818.2015.1046826.

My, N.H.D., Demont, M., Van Loo, E.J., de Guia, A., Rutsaert, P., Tuan, T.H. and Verbeke, W. 2018. What is the value of sustainably-produced rice? Consumer evidence from experimental auctions in Vietnam. *Food Policy.* 79: 283-296. 10.1016/j.foodpol.2018.08.004.

Nandi, R., Krupnik, T.J. and Kabir, W. 2024. Crop diversification in Bangladesh: Public policy provisions, practices, and insights for future initiatives. *Journal of Agriculture and Food Research.* 18: 101486. https://doi.org/10.1016/j.jafr.2024.101486.

Nayak, A.K.J.R. 2018. Economies of scope: context of agriculture, small family farmers and sustainability. *Asian Journal of German and European Studies.* 3(1): 2. 10.1186/s40856-018-0024-y.

Nazari Nooghabi, S., Fleskens, L., Sietz, D. and Azadi, H. 2020. Typology of vulnerability of wheat farmers in Northeast Iran and implications for their adaptive capacity. *Climate And Development.* 12(8): 703-716. 10.1080/17565529.2019.1679072.

Ngan, P.H. and Babu, S.C. 2018. *Agriculture Extension in Viet Nam: An Assessment and Reform Options*. International Food Policy Research Institute, Washington.

Nguyen, A.T. and Hens, L. 2021. Diversified responses to contemporary pressures on sloping agricultural land: Thai farmer's perception of mountainous landscapes in northern Vietnam. *Environment, Development and Sustainability.* 23(4): 5411-5429. http://doi.org/10.1007/s10668-020-00822-x.

Nguyen, M.T., Renaud, F.G. and Sebesvari, Z. 2019. Drivers of change and adaptation pathways of agricultural systems facing increased salinity intrusion in coastal areas of the Mekong and Red River deltas in Vietnam. *Environmental Science and Policy.* 92: 331-348.

Nguyen, N., Mobsby, D. and Goesch, T. 2016. Farm-to-retail price spread and farm share in food supply chains: Background paper. *Canberra: ABARE.*

Nguyen, Q.H. 2017. Analyzing the economies of crop diversification in rural Vietnam using an input distance function. *Agricultural Systems.* 153: 148-156. 10.1016/j.agsy.2017.01.024.

Nguyen, T.B., Le, V.T.T., Nguyen, A.M., Nguyen, N.M. and Nguyen, H.T. 2021. Drivers of agricultural transformation in the coastal areas of the Vietnamese Mekong delta. *Environmental Science and Policy.* 122: 49-58. 10.1016/j.envsci.2021.04.010.

Nguyen, T.T., Do, M.H., Rahut, D.B., Nguyen, V.H. and Chhay, P. 2023. Female leadership, internet use, and performance of agricultural cooperatives in Vietnam. *Annals of Public and Cooperative Economics.* 94(3): 877-903. 10.1111/apce.12434.

Nguyen, V.K., Nguyen, H.H. and Cramb, R. 2020a. Trends in rice-based farming systems in the Mekong Delta. In: Cramb, R. (ed.) *White Gold. The Commercialisation of Rice Farming in the Lower Mekong Basin*. Palgrave Macmillan, Singapore. pp. 347-373.

Nguyen, V.K., Nguyen, H.H. and Cramb, R. 2020b. Trends in Rice-Based Farming Systems in the Mekong Delta. In: *White Gold: The Commercialisation of Rice Farming in the Lower Mekong Basin*. Springer, Singapore. pp. 347-373.

Nikam, V., Ashok, A. and Pal, S. 2022. Farmers' information needs, access and its impact: Evidence from different cotton producing regions in the Maharashtra state of India. *Agricultural Systems.* 196: 103317. 10.1016/j.agsy.2021.103317.

Ninh, N.T.H. 2020. *How to Value Labour in Agricultural Production: A Case Study in the Red River Delta in Vietnam*. University of Liège, Gembloux Agro-Bio Tech, Gembloux.

Ojo, T.O. and Baiyegunhi, L.J.S. 2020. Determinants of climate change adaptation strategies and its impact on the net farm income of rice farmers in south-west Nigeria. *Land Use Policy.* 95: 103946. https://doi.org/10.1016/j.landusepol.2019.04.007.

Pacini, G.C., Colucci, D., Baudron, F., Righi, E., Corbeels, M., Tittonell, P. and Stefanini, F.M. 2014. Combining multi-dimensional scaling and cluster analysis to describe the diversity of rural households. *Experimental Agriculture.* 50(3): 376-397. 10.1017/S0014479713000495.

Pedroso, R., Tran, D.H., Thi, M.H.N., Le, A.V., Ribbe, L., Dang, K.T. and Le, K.P. 2017. Cropping systems in the Vu Gia Thu Bon river basin, Central Vietnam: On farmers' stubborn persistence in predominantly cultivating rice. *NJAS: Wageningen Journal of Life Sciences.* 80(1): 1-13. 10.1016/j.njas.2016.11.001.

Pham, T.T.H., Revilla Diez, J. and Garschagen, M. 2021. A typology of household livelihood changes in rural coastal areas of the Vietnamese Mekong Delta—Capturing the heterogeneity and complexity of the social-ecological context. *Singapore Journal of Tropical Geography.* 42(2): 241-263. 10.1111/sjtg.12335.

Pham, V.H.T., Febriamansyah, R., Afrizal and Tran, T.A. 2018. Government Intervention and Farmers' Adaptation to Saline Intrusion: A Case Study in the Vietnamese Mekong Delta. *International Journal on Advanced Science, Engineering and Information Technology.* 8(5): 2142-2148.

Phuong, L.T.H., Biesbroek, G.R. and Wals, A.E.J. 2018a. Barriers and enablers to climate change adaptation in hierarchical governance systems: the case of Vietnam. *Journal of Environmental Policy & Planning.* 20(4): 518-532. 10.1080/1523908X.2018.1447366.

Phuong, L.T.H., Wals, A., Sen, L.T.H., Hoa, N.Q., Van Lu, P. and Biesbroek, R. 2018b. Using a social learning configuration to increase Vietnamese smallholder farmers' adaptive capacity to respond to climate change. *Local Environment.* 23(8): 879-897. 10.1080/13549839.2018.1482859.

Phuong-Dung, L., Grazia, P., Peter, L., Hoang, L. and Han, V.D. 2025. Climate change and adaptation through the human security lens: insights from the Mekong Delta. *International Development Planning Review.* 0(0): 1-22. 10.3828/idpr.2025.6.

Pingali, P. and Abraham, M. 2022. Food systems transformation in Asia – A brief economic history. *Agricultural Economics.* 53(6): 895-910. 10.1111/agec.12734.

Poon, K. and Weersink, A. 2011. Factors affecting variability in farm and off-farm income. *Agricultural Finance Review.* 71(3): 379-397. 10.1108/00021461111177639.

Poulton, C., Kydd, J. and Dorward, A. 2006. Overcoming market constraints on pro-poor agricultural growth in Sub-Saharan Africa. *Development policy review.* 24(3): 243-277.

R Core Team. 2022a. *The R Project for Statistical Computing*. R Foundation for Statistical Computing, Vienna,.

R Core Team. 2022b. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna.

Rahman, S. 2003. Profit efficiency among Bangladeshi rice farmers. *Food Policy.* 28(5): 487-503. 10.1016/j.foodpol.2003.10.001.

Rahman, S. and Rahman, M. 2009. Impact of land fragmentation and resource ownership on productivity and efficiency: The case of rice producers in Bangladesh. *Land Use Policy.* 26(1): 95-103. 10.1016/j.landusepol.2008.01.003.

Roberts, M.J. and Schlenker, W. 2013. Identifying Supply and Demand Elasticities of Agricultural Commodities: Implications for the US Ethanol Mandate. *American Economic Review.* 103(6): 2265–95. 10.1257/aer.103.6.2265.

Rodríguez-Bustos, L., Galicia, L., Benítez, M., Palacios-Rojas, N. and Ramos, I. 2023. Implementing the nature's contributions framework: A case study based on farm typologies in small-scale agroecosystems from the Mexico highlands. *Frontiers in Sustainable Food Systems.* 7. 10.3389/fsufs.2023.1009447.

Sadik-Rozsnyai, O. and Bertrandias, L. 2019. New technological attributes and willingness to pay: the role of social innovativeness. *European Journal of Marketing.* 53(6): 1099-1124. 10.1108/EJM-12-2016-0834.

Samper, L.F., Giovannucci, D. and Vieira, L.M. 2017. *The powerful role of intangibles in the coffee value chain*. WIPO.

Sánchez, A.C., Kamau, H.N., Grazioli, F. and Jones, S.K. 2022. Financial profitability of diversified farming systems: A global meta-analysis. *Ecological Economics.* 201: 107595. https://doi.org/10.1016/j.ecolecon.2022.107595.

Sarker, M.R., Galdos, M.V., Challinor, A.J. and Hossain, A. 2021. A farming system typology for the adoption of new technology in Bangladesh. *Food and Energy Security.* 10(3): e287. 10.1002/fes3.287.

Schmitt, J., Offermann, F., Ribeiro, A.F. and Finger, R. 2024. Drought risk management in agriculture: A copula perspective on crop diversification. *Agricultural Economics.*

Schneider, P. and Asch, F. 2020. Rice production and food security in Asian Mega deltas—A review on characteristics, vulnerabilities and agricultural adaptation options to cope with climate change. *Journal of Agronomy and Crop Science.* 206(4): 491-503. 10.1111/jac.12415.

Shepherd, A. 2007. *Approaches to linking producers to markets*. Food & Agriculture Org.

Shukla, R., Agarwal, A., Gornott, C., Sachdeva, K. and Joshi, P.K. 2019. Farmer typology to understand differentiated climate change adaptation in Himalaya. *Scientific Reports.* 9(1): 20375. 10.1038/s41598-019-56931-9.

Siders, A.R. 2019. Adaptive capacity to climate change: A synthesis of concepts, methods, and findings in a fragmented field. *WIREs Climate Change.* 10(3): e573. 10.1002/wcc.573.

Sinha, A., Basu, D., Priyadarshi, P., Ghosh, A. and Sohane, R.K. 2022. Farm typology for targeting extension interventions among smallholders in tribal villages in Jharkhand State of India. *Frontiers in Environmental Science.* 10: Online. 10.3389/fenvs.2022.823338.

Stringer, L.C., Fraser, E.D.G., Harris, D., Lyon, C., Pereira, L., Ward, C.F.M. and Simelton, E. 2020. Adaptation and development pathways for different types of farmers. *Environmental Science & Policy.* 104: 174-189. 10.1016/j.envsci.2019.10.007.

Stuart, A.M., Devkota, K.P., Sato, T., Pame, A.R.P., Balingbing, C., My Phung, N.T., Kieu, N.T., Hieu, P.T.M., Long, T.H., Beebout, S. and Singleton, G.R. 2018. On-farm assessment of different rice crop management practices in the Mekong Delta, Vietnam, using sustainability performance indicators. *Field Crops Research.* 229: 103-114. 10.1016/j.fcr.2018.10.001.

Suwanmaneepong, S., Kerdsriserm, C., Lepcha, N., Cavite, H.J. and Llones, C.A. 2020. Cost and return analysis of organic and conventional rice production in Chachoengsao Province, Thailand. *Organic Agriculture.* 10(3): 369-378. 10.1007/s13165-020-00280-9.

Tamura, M., Yasuhara, K., Ajima, K., Trinh, V.C. and Pham, S.V. 2018. Vulnerability to climate change and residents' adaptations in coastal areas of Soc Trang Province, Vietnam. *International Journal of Global Warming.* 16: 102-117. https://doi.org/10.1504/IJGW.2018.094312.

Tan, L.V., Tran, T. and Loc, H.H. 2020. Soil and Water Quality Indicators of Diversified Farming Systems in a Saline Region of the Mekong Delta, Vietnam. *Agriculture.* 10(2): 38.

Tey, Y.S. and Brindal, M. 2015. Factors Influencing Farm Profitability. In: Lichtfouse, E. (ed.) *Sustainable Agriculture Reviews: Volume 15*. Springer International Publishing, Cham. pp. 235-255.

Thach, K.S.R., Lee, J.Y., Ha, M.T., Cao, M.T., Nayga, R.M. and Yang, J.-E. 2023. Effect of saline intrusion on rice production in the Mekong River Delta. *Heliyon.* 9(10). 10.1016/j.heliyon.2023.e20367.

Thanh, H.X., Anh, D.N. and Tacoli, C. 2005. *Livelihood Diversification and Rural-Urban Linkages in Vietnam's Red River Delta*. International Food Policy Research Institute, Washington.

The Anh, D., Van Tinh, T. and Ngoc Vang, N. 2020. The Domestic Rice Value Chain in the Mekong Delta. In: Cramb, R. (ed.) *White Gold: The Commercialisation of Rice Farming in the Lower Mekong Basin*. Springer Nature Singapore, Singapore. pp. 375-395.

Tho, L.C.B. and Umetsu, C. 2022. Rice variety and sustainable farming: A case study in the Mekong Delta, Vietnam. *Environmental Challenges.* 8: 100532. https://doi.org/10.1016/j.envc.2022.100532.

To-The, N. and Nguyen-Anh, T. 2021. Market-oriented extension and farming efficiency in small-scale maize farmers: evidence from Northern Vietnam. *Journal of Agribusiness in Developing and Emerging Economies.* 11(2): 194-218. 10.1108/JADEE-05-2020-0101.

Tran, D.D., Dang, M.M., Du Duong, B., Sea, W. and Vo, T.T. 2021a. Livelihood vulnerability and adaptability of coastal communities to extreme drought and salinity intrusion in the Vietnamese Mekong Delta. *International Journal of Disaster Risk Reduction.* 57: 102183. 10.1016/j.ijdrr.2021.102183.

Tran, D.D., Hoang, L.P. and Tran, T.A. 2024a. Farmers' livelihoods and adaptation in the Vietnamese Mekong Delta: Current practices and policy implications. In: *The Mekong River Basin*. Elsevier. pp. 527-558.

Tran, D.D., Nguyen, T.D., Park, E., Nguyen, T.D., Pham Thi Anh, N., Vo, T.T. and Nguyen, A.H. 2023. Rural out-migration and the livelihood vulnerability under the intensifying drought and salinity intrusion impacts in the Mekong Delta. *International Journal of Disaster Risk Reduction.* 93: 103762. https://doi.org/10.1016/j.ijdrr.2023.103762.

Tran, D.D., Park, E., Tuoi, H.T.N., Thien, N.D., Tu, V.H., Anh Ngoc, P.T., Van, C.T., Kim Long, P., Ho, H.L. and Quang, C.N.X. 2022a. Climate change impacts on rice-based livelihood vulnerability in the lower Vietnamese Mekong Delta: Empirical evidence from Can Tho City and Tra Vinh Province. *Environmental Technology & Innovation.* 28: 102834. https://doi.org/10.1016/j.eti.2022.102834.

Tran, D.D., Quang, C.N.X., Tien, P.D., Tran, P.G., Kim Long, P., Van Hoa, H., Ngoc Hoang Giang, N. and Thi Thu Ha, L. 2020a. Livelihood Vulnerability and Adaptation Capacity of Rice Farmers under Climate Change and Environmental Pressure on the Vietnam Mekong Delta Floodplains. *Water.* 12(11): 3282. 10.3390/w12113282.

Tran, D.D., van Halsema, G., Hellegers, P.J.G.J., Ludwig, F. and Wyatt, A. 2018. Questioning triple rice intensification on the Vietnamese mekong delta floodplains: An environmental and economic analysis of current land-use trends and alternatives. *Journal of Environmental Management.* 217: 429-441. 10.1016/j.jenvman.2018.03.116.

Tran, T.A. and Cook, B.R. 2024. Water retention for agricultural resilience in the Vietnamese Mekong Delta: towards integrated 'grey–green' solutions. *International Journal of Water Resources Development.* 40(3): 532-553. 10.1080/07900627.2023.2207674.

Tran, T.A., Dang, T.D., Nguyen, T.H. and Pham, V.H.T. 2021b. Moving towards sustainable coastal adaptation: Analysis of hydrological drivers of saltwater intrusion in the Vietnamese Mekong Delta. *Science of The Total Environment.* 770: 145125. 10.1016/j.scitotenv.2021.145125.

Tran, T.A., Helen, J. and and Nhan, D.K. 2020b. Effects of social learning on rural farmers' adaptive capacity: Empirical insights from the Vietnamese Mekong Delta. *Society & Natural Resources.* 33(9): 1053-1072. 10.1080/08941920.2019.1693677.

Tran, T.A., Nguyen, T.H. and Vo, T.T. 2019. Adaptation to flood and salinity environments in the Vietnamese Mekong Delta: Empirical analysis of farmer-led innovations. *Agricultural Water Management.* 216: 89-97. https://doi.org/10.1016/j.agwat.2019.01.020.

Tran, T.A. and Touch, V. 2024. How agricultural extension responds to amplified agrarian transitions in mainland Southeast Asia: experts' reflections. *Agriculture and Human Values.* 10.1007/s10460-024-10577-0.

Tran, T.B., Tran, T.Q. and Pham, T.M.A. 2024b. Economic and Environmental Impacts of Land Consolidation on Rice Farm Performance in Vietnam. *Human Ecology.* 52(4): 785-796. 10.1007/s10745-024-00525-1.

Tran, T.Q. and Vu, H.V. 2019. Land fragmentation and household income: First evidence from rural Vietnam. *Land Use Policy.* 89: 104247. 10.1016/j.landusepol.2019.104247.

Tran, V.T., An-Vo, D.-A., Mushtaq, S. and Cockfield, G. 2022b. Nuanced assessment of livelihood resilience through the intersectional lens of gender and ethnicity: Evidence from small-scale farming communities in the upland regions of Vietnam. *Journal of Rural Studies.* 92: 68-78. 10.1016/j.jrurstud.2022.03.011.

Trang, N.T. and Tu, V.H. 2024. Performance of Rice Cooperatives in the Vietnamese Mekong Delta: Initiatives for Sustainable and Organic-Oriented Agricultural Development. *Journal of Positive Psychology and Wellbeing.* 8(2): 72–85-72–85.

Trong, T.A. 2016. *Flood Governance in the Mekong Delta of Vietnam: Implications of Social Learning for Household and Institutional Adaptation*. The Australian National University, Canberra.

Trostle, R. 2008. Global agricultural supply and demand: factors contributing to the recent increase in food commodity prices.

Truong, T.L., Nanseki, T. and Chomei, Y. 2015. Identification of information sources influencing the technical inefficiency of crop farmers in Vietnam. *Asian Journal of Science and Technology.* 6: 1677-1683.

Tu, V.H., Kopp, S.W., Trang, N.T., Hong, N.B. and Yabe, M. 2021. Land accumulation: An option for improving technical and environmental efficiencies of rice production in the Vietnamese Mekong Delta. *Land Use Policy.* 108: 105678. https://doi.org/10.1016/j.landusepol.2021.105678.

Tuan, L.A., Hoanh, C.T., Miller, F. and Sinh, B.T. 2007. Flood and Salinity Management in the Mekong Delta, Vietnam. In: Be, T.T., Sinh, B.T. and Miller, F. (eds.) *Challenges to sustainable development in the Mekong Delta: Regional and national policy issues and research needs: Literature analysis*. The Sustainable Mekong Research Network (Sumernet) pp.15-68, Bangkok, Thailand.

Tuladhar, S., Hussain, A., Baig, S., Ali, A., Soheb, M., Angchuk, T., Dimri, A.P. and Shrestha, A.B. 2023. Climate change, water and agriculture linkages in the upper Indus basin: A field study from Gilgit-Baltistan and Leh-Ladakh. *Frontiers in Sustainable Food Systems.* 6. 10.3389/fsufs.2022.1012363.

Turner, S., Derks, A. and Thúy Hạnh, N. 2019. Flex crops or flex livelihoods? The story of a volatile commodity chain in upland northern Vietnam. *The Journal of Peasant Studies.* 46(2): 276-296. 10.1080/03066150.2017.1382477.

Ugwumba, C.O., Okoh, R.N., Ike, P.C., Nnabuife, E.L.C. and Orji, E.C. 2010. Integrated farming system and its effect on farm cash income in Awka South agricultural zone of Anambra state, Nigeria. *American-Eurasian Journal of Agricultural and Environmental Science.* 8: 1-6.

UNDP and VCCI. 2022. *Agricultural Transformation Model Adapting to Climate Change in the Mekong Delta*. Vietnam Chamber of Commerce and Industry, and United Nations Development Programme, Can Tho.

USAID. 2022. *Mekong Delta Climate Resilient Agriculture Activity Design*. United States Agency for International Development, Hanoi.

van Aalst, M.A., Koomen, E. and de Groot, H.L.F. 2023a. Vulnerability and Resilience to Drought and Saltwater Intrusion of Rice Farming Households in the Mekong Delta, Vietnam. *Economics of Disasters and Climate Change.* 7(3): 407-430. 10.1007/s41885-023-00133-1.

van Aalst, M.A., Koomen, E., Tran, D.D., Hoang, H.M., Nguyen, H.Q. and de Groot, H.L.F. 2023b. The economic sustainability of rice farming and its influence on farmer decision-making in the upper Mekong delta, Vietnam. *Agricultural Water Management.* 276: 108018. 10.1016/j.agwat.2022.108018.

Van Phan, P. and O'Brien, M. 2022. Is small beautiful? An empirical analysis of land characteristics and rural household income in Vietnam. *Australian Journal of Agricultural and Resource Economics.* 66(3): 561-580. 10.1111/1467-8489.12476.

Vanclay, F. 2004. Social Principles for Agricultural Extension to Assist in the Promotion of Natural Resource Management. *Australian Journal of Experimental Agriculture.* 44: 213-222. 10.1071/EA02139.

Võ, T.T.L. 2016. Assessment of agri-product value chains in the Mekong Delta: Problems and solutions. *Can Tho University Journal of Science.* 2: 100-111.

von Cramon-Taubadel, S. and Goodwin, B.K. 2021. Price transmission in agricultural markets. *Annual Review of Resource Economics.* 13(1): 65-84.

Vorley, B., Lundy, M. and MacGregor, J. 2009. Business models that are inclusive of small farmers. In: *Agro-industries for development*. CABI Wallingford UK. pp. 186-222.

Vu, D.T., Yamada, T. and Ishidaira, H. 2018. Assessing the impact of sea level rise due to climate change on seawater intrusion in Mekong Delta, Vietnam. *Water Science and Technology.* 77(6): 1632-1639. 10.2166/wst.2018.038.

Vu, H.L. 2020. Estimation and analysis of food demand patterns in Vietnam. *Economies.* 8(1): 11. http://doi.org/10.3390/economies8010011.

Vukadinović, P., Damnjanović, A. and Ranđić, J.K. 2017. The analysis of indiference and the price elasticity of demand between different categories of agricultural products. *Economics of Agriculture.* 64(2): 671-685.

Wickramasinghe, U., Omot, N., Patiken, A.D. and Ryan, J. 2014. *Market Participation of Smallholder Agricultural Households in Papua New Guinea*. CAPSA-ESCAP, Bogor.

Wooldridge, J.M. 2013. *Introductory Econometrics: A Modern Approach*. South-Western Cengage Learning, Mason, Ohio.

World Bank. 2016a. *Mekong Delta integrated climate resilience and sustainable livelihoods project*. World Bank, Washington.

World Bank. 2016b. *Transforming Vietnamese Agriculture: Gaining More for Less*. Hong Duc Publishing House, Hanoi.

World Bank. 2016c. Viet Nam - Mekong Delta Integrated Climate Resilience and Sustainable Livelihoods Project : IDA Implementation Completion Mission and GEF Implementation Support Mission - November 29th-December 11th, 2024 (English). In. World Bank Group, Washington, D.C.

Xiang, M., Yu, Q., Li, Y., Shi, Z. and Wu, W. 2022. Increasing multiple cropping for land use intensification: The role of crop choice. *Land Use Policy.* 112: 105846. 10.1016/j.landusepol.2021.105846.

Yadav, L.P., Smith, D., Aziz, A.A., Thuy, C.T.L., Thao, H.X., Le, H.H., Nicetic, O., Quyen, L.N. and Vagneron, I. 2021. Can traders help farmers transition towards more sustainable maize based farming systems? Evidence from the Lao-Vietnamese border. *International Journal of Agricultural Sustainability.* 19(3-4): 234-254. 10.1080/14735903.2021.1901466.

Yadav, V.S., Singh, A.R., Gunasekaran, A., Raut, R.D. and Narkhede, B.E. 2022. A systematic literature review of the agro-food supply chain: Challenges, network design, and performance measurement perspectives. *Sustainable Production and Consumption.* 29: 685-704. 10.1016/j.spc.2021.11.019.

Zang, Y., Yang, Y. and Liu, Y. 2021. Toward serving land consolidation on the table of sustainability: An overview of the research landscape and future directions. *Land Use Policy.* 109: 105696. 10.1016/j.landusepol.2021.105696.