Upgrading Horticultural Value Chains for Enhanced Welfare and Food Security – Case Studies from Thailand and Kenya

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Zusammenfassung

Die zunehmende Urbanisierung in Südostasien und Ostafrika in den letzten Jahren hat zu einem starken Anstieg der Nachfrage nach kommerziell produzierten Gartenbauprodukten und zu steigenden Erwartungen der Endverbraucher*innen an die Produktqualität und Lebensmittelsicherheit geführt. Die städtischen Endverbraucher in diesen Regionen sind zunehmend bereit, höhere Preise für hochwertige Gartenbauprodukte zu zahlen. Für die Landwirt*innen im ländlichen Raum ist dies potenziell eine positive Entwicklung, denn die Verbesserung der regionalen Wertschöpfungsketten und die zunehmende Kommerzialisierung der Produktion können ihr Einkommen verbessern und auch die wirtschaftliche Entwicklung in den ländlichen Gebieten ankurbeln. Darüber hinaus kann die Modernisierung der gärtnerischen Wertschöpfungsketten einen positiven Einfluss auf die Ernährungssicherheit der Bevölkerung der Region haben, indem sie die Verfügbarkeit von sicherem Obst und Gemüse auf den lokalen Märkten erhöht. Dies ist besonders wichtig für Ostafrika und Südostasien, wo Mikronährstoffmangel durch zu geringe Aufnahme von Obst und Gemüse nach wie vor ein sehr dominantes Problem ist.

Trotz dieser Vorteile ist die Implementierung von Modernisierungen in der kommerziellen Gartenbauproduktion nach wie vor eine Herausforderung für Kleinbäuerinnen und Kleinbauern in Südostasien und Ostafrika. Dies liegt auch an der unzureichenden Forschung auf diesem Gebiet, da sich die bisherige Forschung eher auf die Modernisierung der globalen gartenbaulichen Wertschöpfungsketten konzentriert hat, mit Schwerpunkt auf gartenbaulichen Exportprodukten und privaten Standards. Produkte für den lokalen Markt im globalen Süden wurden bisher nur selten untersucht – ebenso öffentliche Produktstandards für Gartenbauprodukte. Auch über das Marktpotenzial von einheimischem Gemüse in Ostafrika ist bisher wenig bekannt. Darüber hinaus geht die aktuelle Forschung oft nur implizit davon aus, dass ein hoher Mikronährstoffgehalt der produzierten Früchte und Gemüse zu einer höheren Ernährungssicherheit und -vielfalt der sie produzierenden Haushalte führen wird.

Diese Arbeit zielt darauf ab, zum Schließen dieser Forschungslücken beizutragen, indem zuerst die Entscheidungsprozesse zur Annahme von Modernisierungsstrategien in den Wertschöpfungsketten untersucht und dann die Auswirkungen dieser Entscheidungen auf den Einkommens- und Ernährungssicherheitsstatus der Haushalte bewertet werden. Untersucht werden diese Parameter anhand der Exportwertschöpfungskette von Mango und Orchideen in Thailand und anhand der lokalen Wertschöpfungskette von afrikanischem einheimischen Gemüse (AIV) in Kenia. Darüber hinaus werden

indirekte wirtschaftliche Auswirkungen der kommerziellen Produktion von gartenbaulichen Nahrungsmitteln in den wichtigsten AIV-Produktionsgebieten Kenias bewertet. Dazu werden die folgenden spezifischen Forschungsfragen gestellt: a) was veranlasst Orchideen- und Mangoproduzent*innen in Thailand, den Q-GAP-Standard zu übernehmen und wie wirkt sich diese Entscheidung auf ihr Einkommen und ihre Exportanteile aus, b) wie stellt sich die Ernährungssicherheit im ländlichen und peri-urbanen Kenia dar und was sind die Merkmale von ernährungsunsicheren Haushalten, c) welche Faktoren beeinflussen die Einführung von AIVs als kommerzielle Nutzpflanze, d) welche Auswirkungen hat die Fokussierung auf AIVs als kommerzielle Nutzpflanze auf Einkommen und Ernährungssicherheit der produzierenden Haushalte, e) welche Gartenbaukulturen haben die höchsten direkten und indirekten Einkommenseffekte für ernährungsunsichere Haushalte im ländlichen und peri-urbanen Kenia? Diese Forschungsfragen werden in den Kapiteln 2 - 4 der Arbeit beantwortet.

In Kapitel 2 wird die Forschungsfrage a) zur exportorientierten Zertifizierung in Thailand bewertet. Dazu wurde ein binäres Probit-Modell und Propensity Score Matching (PSM) auf Primärdaten von 400 zertifizierten und nicht zertifizierten Orchideen- und Mango-Produzent*innen aus den wichtigsten Exportprovinzen Thailands angewendet. Die Schätzungen des binären Probit-Modells zeigen, dass die Orchideen- und Mango-Produzent*innen mit Hochschulbildung und mehr physischem und sozialem Kapital die Annahme des Q-GAP-Standards preferieren. Die Ergebnisse des PSMs zeigen, dass die Annahme öffentlicher GAP-Standards zu positiven Einkommenseffekten für Mangoproduzent*innen führt, nicht aber für Orchideenproduzent*innen. Dies lässt sich dadurch erklären, dass zertifizierte Mango-Produzent*innen ihre Produkte an hochwertige Einzelhandelsketten verkaufen können, die höhere Preise für ihre Produkte bieten, während zertifizierte und nicht zertifizierte Orchideen in der gleichen Lieferkette vermarktet werden.

In Kapitel 3 werden die Faktoren, die Kleinbäuerinnen und Kleinbauern motivieren, sich auf AIVs als kommerzielle Nutzpflanze zu spezialisieren, anhand eines binären Probit-Modells untersucht. Darüber hinaus werden eine Endogenous Switching Regression (ESR) und ein binäres und ein kontinuierliches PSM angewendet, um die Auswirkungen der AIV-Produktion auf das Einkommen und die Ernährungssicherheit der Haushalte zu bewerten. Die Indikatoren für die Ernährungssicherheit werden auf der Grundlage der FAO-Definition für Ernährungssicherheit ausgewählt und umfassen den wirtschaftlichen und physischen Zugang zu Nahrungsmitteln, die Nahrungsmittelnutzung und -stabilität. Die Analyse basiert auf Primärdaten von 706 ländlichen und peri-urbanen kleinen Gemüseproduzent*innen in Kisii, Kakamega, Nakuru und Kiambu in Kenia. Die Ergebnisse zeigen, dass

höhere formale Bildung, die Beteiligung an Erzeugergemeinschaften, der Zugang zu Marktinformationen und ein umfangreiches soziales Netzwerk die Entscheidung, AIVs zu verkaufen, positiv beeinflussen. Infrastrukturaspekte wie die Entfernung zur nächsten Stadt und der Zugang zu Bewässerungswasser wirken sich ebenfalls positive auf die Entscheidung aus. Die Produktion von AIVs als kommerzielle Nutzpflanzen beeinflusst das Pro-Kopf-Haushaltseinkommen und insbesondere die Zugangs- und Stabilitätsdimensionen der Ernährungssicherheit positiv.

Kapitel 4 befasst sich mit der Ernährungssicherheit und den wirtschaftlichen Auswirkungen der Gartenbauproduktion aus einer weitergefassten Perspektive mit der Konstruktion einer Social Accounting Matrix (SAM) für Gebiete mit hoher AIV-Produktion in Kenia. Die SAM basiert auf 706 ländlichen und peri-urbanen kleinen Gemüseproduzenten in Kenia. Sekundärdaten werden verwendet, um fehlende Elemente zu ergänzen und die Ergebnisse zu validieren. Die Haushalte werden nach ihrem Ernährungssicherheitsstatus nach der Definition der FAO zur Ernährungssicherheit zusammengefasst. Die Ergebnisse zeigen eine signifikant höhere Prävalenz der Ernährungsunsicherheit in den ländlichen Gebieten, insbesondere in der Nutzungs- und Stabilitätsdimension. Lebensmittelsichere Erzeuger*innen verfügen im Vergleich zu lebensmittelunsicheren Erzeuger*innen über ein höheres Bildungsniveau und mehr Land, erwirtschaften mehr Einkommen aus der Beschäftigung außerhalb der Landwirtschaft und weniger aus der Pflanzenproduktion. AIVs haben in der Dorfwirtschaft einen höheren Multiplikatoreffekt als viele andere Nutzpflanzen wie Kaffee, Tee oder Mais. Dies gilt insbesondere für die weniger häufig produzierten AIVs wie Murenda, Kürbisblätter und Enderema. Aufgrund ihres Ernährungsnutzens und der Auswirkungen auf die regionale Wirtschaft sollte die Produktion von AIVs in ländlichen und peripheren Gebieten Kenias weiter gefördert werden.

Kapitel 5 zielt darauf ab, die Leistung von AIV-Wertschöpfungsketten anhand von Paneldaten aus ländlichen, peri-urbanen und städtischen Gebieten Kenias in den Jahren 2014, 2015 und 2016 zu analysieren, wobei der Fokus auf Produzent*innen, Händler*innen und Verbraucher*innen von AIVs liegt. Beschreibende Statistiken werden verwendet, um Produktions- und Marketingpraktiken von AIV-Landwirt*innen zu beschreiben und Herausforderungen und Chancen der AIV-Wertschöpfungskette aus der Sicht von Händler*innen und Verbraucher*innen zu bewerten. Ein Ordered Probit Modell wird verwendet um die wichtigsten Einflussfaktoren in der Entscheidung zu analysieren, ob die Produzent*innen in Gruppen vermarkten. Die Ergebnisse zeigen, dass die Produktion von AIVs in den letzten fünf Jahren vor allem durch intensivere Produktionstechniken, als durch eine Vergrößerung der AIV-Kulturfläche gestiegen ist. Trotz des Einkommenspotenzials der Nutzpflanzen produzieren die

meisten Landwirt*innen immer noch AIVs als Subsistenzpflanze und verkaufen Überschüsse auf den lokalen Märkten ohne Verträge und mit begrenzter Verpackung und Nacherntebehandlung. Von den Produzent*innen, die ihre AIVs vermarkten, tun dies die meisten einzeln, mit höheren Vermarktungsraten in Gruppen in Kakamega und Kisii. Wirtschaftlich besser gestellte Haushalte mit jüngeren, männlichen Haushaltsentscheidern sowie Zugang zu Krediten und moderner Bewässerungstechnik vermarkten ihre AIVs eher in Gruppen. In Nairobi werden die meisten AIVs auf Freiluftmärkten verkauft. Die Verbraucher*innen in Nairobi kaufen am liebsten auf diesen Märkten, vor allem, weil sie in der Nähe ihrer Häuser sind und frisches Gemüse zu erschwinglichen Preisen anbieten. Das Vertrauen in die Lebensmittelsicherheit von Gemüse ist eines der wichtigsten Kriterien für die Verbraucher*innen, um bei einem bestimmten AIV-Händler zu bleiben. Eines der größten Probleme für die Verbraucher*innen in Nairobi ist, dass AIVs nicht das ganze Jahr über zu erschwinglichen Preisen erhältlich sind, was den Bedarf an Bewässerung und geeigneten Lagereinrichtungen auf der Produktions- und Handelsseite der Kette zeigt.

Schlagwörter: Ernährungssicherheit; Haushaltswohlfahrt; Kommerzialisierung von Kleinbauern; Orchideen; Mangos; Q-GAP; afrikanisches einheimisches Gemüse; Thailand; Kenia; binäres Probit-Modell; Ordered-Probit-Modell; Propensity Score Matching; Endogenous Switching Regression; Social Accounting Matrix

Abstract

Increasing urbanization in Southeast Asia and East Africa in recent years has led to strong increases in demand for commercially produced horticultural products and increasing expectations from end customers regarding product quality and food safety. Urban end customers in these regions are increasingly willing to pay high prices for high-quality horticultural products. For farmers in rural areas, this is potentially a positive development because upgrading regional value chains and increasing the commercialization of horticultural production can enhance farmers' income and spur economic development in rural areas. Furthermore, upgrading horticultural value chains can have a positive influence on the food security of the region's populations through the increased availability of safe fruits and vegetables in local markets. This is of particular importance in East Africa and Southeast Asia, where micronutrient deficiencies due to the intake of insufficient fruits and vegetables are still a dominant problem.

Despite these advantages, the adoption of upgraded strategies in commercial horticulture production remains a challenge among smallholder farmers in both Southeast Asia and East Africa. This topic has also been insufficiently researched in the field because much research on upgrading global horticultural value chains with a focus on horticultural export crops and private standards has been carried out. Products for the local market in the global south and public product standards have rarely been studied so far. Also, little is known about the market potential of indigenous vegetables. Furthermore, current research often implicitly assumes that the high micronutrient content of the fruits and vegetables produced will translate into increased food security and dietary diversity in the households producing these fruits and vegetables.

This thesis aimed to fill these gaps in knowledge by evaluating the decisions of small-scale farmers to adopt strategies to upgrade mango and orchid export value chains in Thailand and local African indigenous vegetable (AIV) value chains in Kenya and assessing the impact of those choices on household income food security status. Furthermore, the indirect economic effects of the commercial production of horticultural food crops were evaluated in main AIV production areas in Kenya. To understand these effects, the following specific research questions were raised: a) What makes orchid and mango producers in Thailand adopt the public good agricultural practice standards Q-GAP and how do these standards affect their income and export shares? b) What levels of food security exist in rural and periurban Kenya, and what are the characteristics of food-insecure households? c) What factors influence the adoption of AIVs as cash crops? d) What is the impact of focusing on AIVs as cash crops on

income and food security? e) What horticulture crop has the best direct and indirect income effects on food-insecure households in rural and periurban Kenya? These research questions are answered in chapters 2-4 of this thesis.

Chapter 2 evaluates research question a), which is related to export promoting certification in Thailand. To examine this research question, a binary choice model and propensity score matching (PSM) were applied to primary data from 400 certified and noncertified orchid and mango producers from main exporting provinces in Thailand. Binary probit model estimations showed that orchid and mango producers with higher levels of education and more physical and social capital tend to comply with Q-GAP standards. The results from the PSM approach revealed that adoption of public GAP standards has positive income effects on mango producers, but not orchid producers. This result can be explained by the fact that certified mango producers can sell their products to high-value retail chains that offer higher prices for their products, while certified and noncertified orchid producers cooperate with traders from the same value chains.

In Chapter 3, the factors motivating small-scale farmers to specialize in AIVs as a cash crop are explored using a binary choice model. Furthermore, endogenous switching regression (ESR) and binary and continuous PSM models were applied to assess the impact of AIV production for cash on household incomes and food security. Food security indicators were chosen based on the FAO's definition of food security and included economic and physical access to food, food utilization and stability. The analysis was based on primary data from 706 rural and periurban small-scale vegetable producers in Kisii, Kakamega, Nakuru and Kiambu in Kenya. A higher level of formal education, producer group participation, access to market information and an extensive social network were shown to positively influence the decision to sell AIVs. Infrastructure aspects, such as distance to the next city and access to water for irrigation, also play a role in the decision to sell AIVs. Producing AIVs as cash crops was found to positively influence total per capita household income and the access and stability dimensions of food security in particular.

Chapter 4 examines the food security and economic effects of horticulture production from a wider perspective by constructing a social accounting matrix (SAM) for areas of high-level AIV production in Kenya. The SAM was constructed based on 706 rural and periurban small-scale vegetable producers in Kenya, and secondary data were used to complement missing elements and validate the findings of the SAM. Households were clustered according to their level of food security following the FAO's definition of food security. The results showed a significantly higher prevalence of food insecurity in rural areas,

especially in the utilization and stability dimension of food insecurity. Food-secure producers have higher levels of education, own more land, and generate more income from off-farm employment and less income from crop production than food-insecure producers. AIVs have higher multiplier effects on the village economy than many cash crops, such as coffee, tea or maize. This is especially true for the less commonly produced AIVs, such as murenda, pumpkin leaves and enderema. The nutritional benefits and effect on AIVs on the regional economy have been suggested to further promote the production of AIVs in rural and periurban areas in Kenya.

Chapter 5 analyzes the performance of AIV value chains using panel data from rural, periurban and urban areas in Kenya in 2014, 2015 and 2016 focusing on the producers, traders and consumers of AIVs. Descriptive statistics were used to describe the production and marketing practices of AIV farmers and evaluate the challenges and opportunities of the AIV value chain from traders' and consumers' perspectives. An ordered probit was used to analyze determinants that influence the decision of AIV producers to market in groups. The production of AIVs increased over the last five years mainly through more intensive production techniques as opposed to an increase in the area under AIV cultivation. Despite the income potential of these crops, most farmers still produce AIVs as subsistence crops and sell surplus in local markets without contracts and with limited packaging and postharvest handling. Of the producers that market their AIVs, most do individually, and higher rates of group marketing are observed in Kakamega and Kisii. Wealthier households with young, male household heads and access to credit and modern irrigation techniques are more likely to market their AIVs in groups. In Nairobi, most AIVs are sold in open-air markets. Consumers in Nairobi prefer buying at open markets mostly because they are close to their homes and they have fresh vegetables for affordable prices. Trust in the safety of the vegetables is one of the major criteria that consumers use when they decide to remain with a specific AIV trader. One of the major problems for consumers in Nairobi is that AIVs are not available throughout the year at affordable prices, showing the need for irrigation and suitable storage facilities at the production and trade side of the chain.

Keywords: Food security; household welfare; smallholder commercialization; orchids; mangoes; Q-GAP; African indigenous vegetables; Thailand; Kenya; binary probit model; ordered probit model; propensity score matching; endogenous switching regression; social accounting matrix

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List of abbreviations

ABM = Agent-based model

AEC = Asian Economic Community

AIV = African indigenous vegetable

ATT = Average treatment effect on the treated

ATU = Average treatment effect on the untreated

BMBF = Bundesministerium für Bildung und Forschung (German Federal Ministry of Education and Research)

BMZ = Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry of Economic Cooperation and Development)

CGE = Computable general equilibrium model

CIA = Conditional independence assumption

CSI = Coping Strategy Index

DAP = Diammonium phosphate

DoAE = Department of Agricultural Extension

ESR = Endogenous switching regression

FAO = Food and Agriculture Organization of the United Nations

FCS = Food Consumption Score

FEWS NET = Famine Early Warning Systems Network

GAP = Good agricultural practice

GPSM = Generalized propensity score matching

HDDS = Household Dietary Diversity Score

HH = Household

Hortinlea = Horticultural Innovation and Learning for Improved Nutrition and Livelihood in East Africa

IMR = Inverse mill ratio

Kshs = Kenyan shillings

MAHFP = Month of Adequate Household Food Provisioning

OAE = Office of Agricultural Extension

OLS = Ordinary least squares

PPP = Purchasing power parity

PSM = Propensity score matching

SAM = Social accounting matrix

SE = Standard error

THB = Thai Baht

WFP = World Food Programme

1. Introduction

1.1. Background of the study

Increasing urbanization in Southeast Asia and East Africa in recent years has led to strong increases in the demand for commercially produced horticultural products (Sautier & Nguyen, 2016). However, demand in not just quantity but also product expectations in terms of quality, food safety and sustainable production processes is increasing. Urban end customers in these regions are increasingly willing to pay high prices for high-quality horticultural products (Pickles et al., 2016; Croft et al., 2014).

For farmers in rural areas, this is potentially a positive development because upgrading regional value chains and increasing the commercialization of horticultural producers has been shown to enhance farmers' incomes and the income and working conditions of hired labor (Barrientos et al., 2016). One way to upgrade the value chain is the implementation of product standards, such as good agricultural practice or food safety standards. In other contexts, farmers first need to shift from subsistence to commercial production to enter the value chain and meet urban demands for fresh horticultural products. With the right preconditions, the producers and processors of locally available fruits and vegetables can have strong impacts on the economic development of rural regions (Sautier & Nguyen, 2016; Mabaya et al., 2014). Small-scale farmers can increase their productivity and income from agricultural activity if they commercialize their crops (Ogutu & Qaim, 2019; Rao et al., 2012).

In addition the economic effects, upgrading horticultural value chains can have a positive influence on the food security of the region's populations if the upgrade increases the availability of safe fruits and vegetables in local markets (Van den Broeck & Maertens, 2016). This effect is of particular importance in East Africa and Southeast Asia, where micronutrient deficiencies due to the intake of insufficient fruits and vegetables are still a dominant problem (UNICEF et al., 2018; FAO et al., 2018).

Nevertheless, the adoption of strategies to upgrade commercial horticulture production remains a challenge among smallholder farmers in both Southeast Asia and East Africa. The main constraints to adopting these strategies are a lack of knowledge, lack of capital and lack of market opportunities (Ayodele et al., 2011; Mbugua et al., 2011). Furthermore, many local horticultural crops are still under-researched, leaving farmers with underdeveloped genetic materials and production systems (Weinberger & Lumpkin, 2005).

Many studies have been conducted on upgrading global horticultural value chains, in most of which producers in the global south produce for retailers in the global north (Henson and Humphrey 2010; Gereffi et al., 2005; Dolan and Humphrey, 2000). Horticultural export crops and private standards in this context have received much attention by researchers (Henson and Humphrey, 2010; Ouma, 2010; Maertens and Swinnen, 2009). However, products for the local market in the global south and public product standards have rarely been studied. In addition, little is known about the market potential of indigenous vegetables. Furthermore, current research often implicitly assumes that the high micronutrient content of the fruits and vegetables produced will translate into increased food security and dietary diversity in the households producing these fruits and vegetables (Raharinaivo et al., 2015; Legwaila et al., 2011; Msuya et al., 2009). Whether commercial horticultural production or upgraded value chains themselves enhance the food security status of producing households has not been robustly tested (Van den Broeck & Maertens, 2016).

This thesis aimed to fill these gaps in knowledge by evaluating the income and food security effects of strategies to upgrade mango and orchid export value chains in Thailand and local African indigenous vegetable (AIV) value chains in Kenya. In Thailand, orchid and mango producers engage in public good agricultural practice scheme Q-GAP to differentiate their products. In Kenya, farmers choose to commercialize indigenous vegetable production. To account for self-selection bias, Propensity Score Matching and Endogenous Switching Regression were used in the analyses. A Social Accounting Matrix (SAM) for the main AIV production regions in Kenya was used to further evaluate the indirect effects of the commercial production of horticultural food crops on the rural economy. To the knowledge of the author, this SAM is the first to integrate aspects of food security in the analysis.

1.2. Research objectives

The overall objective of this study was to evaluate the decision of small-scale farmers to adopt upgraded strategies for domestic and export horticultural value chains and the food security and income effects of these upgrading strategies on households. To assess these effects, the following specific research questions were raised:

1 What makes orchid and mango producers in Thailand adopt Q-GAP standards, and how do these standards affect their incomes and export shares?
2 How do livelihoods between household groups in AIV-producing areas with different levels of food security differ?

3 What are the production practices and marketing strategies used by AIV farmers in the main areas in Kenya in which AIVs are produced?
4 What socioeconomic determinants influence AIV producers' decisions to adopt a certain marketing strategy?
5 What challenges and opportunities for the AIV value chain are visible from traders' and consumers' perspectives?
6 What factors influence the adoption of AIVs as cash crops?
7 What is the impact of focusing on AIVs as cash crops on income and food security?
8 What crops have the highest indirect income effects on rural and periurban economies in AIV-producing areas?
9 What crops have the highest direct income effects on household groups with different levels of food security?

1.3. Structure of the thesis and main findings

The thesis is structured in five chapters (Table 1).

Chapter 1 gives an overview of the problem and states the research objectives. This chapter further elaborates on the main findings in the consequent four chapters, which are articles reporting research conducted in Thailand and Kenya.

Chapter 2 evaluates the factors that influence the decision of orchid and mango producers in Thailand to adopt public Q-GAP standards and how this decision to adopt public Q-GAP standards affects their income and export shares. To examine this issue, a binary choice model and propensity score matching were applied to primary data from 400 certified and noncertified orchid and mango producers from main exporting provinces in Thailand. The binary probit model estimations showed that orchid and mango producers with a higher level of education and more physical and social capital tend to comply with Q-GAP standards. The results from the Propensity Score Matching approach revealed that adoption of public GAP standards results in positive income effects for mango producers, but not orchid producers. This result can be explained by the fact that certified mango producers can sell their products to high-value retail chains that offer higher prices for their products, while certified and noncertified orchid producers cooperate with traders from the same value chain.

In Chapter 3, the factors motivating small-scale farmers to specialize in AIVs as a cash crop are explored using a binary choice model. Furthermore, endogenous switching regression (ESR) and binary and

continuous propensity score matching (PSM) were applied to assess the impact of AIV production for cash on household incomes and food security. Food security indicators were chosen based on the FAO's definition of food security and include economic and physical access to food, food utilization and stability. The analysis was based on primary data from 706 rural and periurban small-scale vegetable producers in Kisii, Kakamega, Nakuru and Kiambu in Kenya. The analysis showed that higher levels of formal education, producer group participation, access to market information and an extensive social network positively influence the decision to sell AIVs. Infrastructure aspects, such as distance to the next city and access to water for irrigation, also play a role. Producing AIVs as cash crops positively influences total per capita household income and the access and stability dimensions of food security in particular.

Table 1: Output of the thesis

Chapter	Title	Authors	Published in/presented at
2	Adoption and Income Effects of Public GAP Standards: Evidence from the Horticultural Sector in Thailand	Henning Krause, Rattiya Suddeephong Lippe, Ulrike Grote	Published in: Horticulturae 2016, 2, 18:1-21 Earlier version presented at: Tropentag 2014, 17.-19.9.2014, Czech University of Life Sciences, Prague, Czech Republic
3	Welfare and Food Security Effects of Commercializing African Indigenous Vegetables in Kenya	Henning Krause, Anja Faße, Ulrike Grote	Published in: Cogent Food & Agriculture Earlier short version published as: Krause, Henning, Faße, Anja, Ulrike Grote (2016): The impact of specializing in African indigenous vegetable production on food security among Kenyan vegetable producers. In: Dirksmeyer, Walter, Schulte, Michael, and Ludwig Theuvsen (Eds.) (2016): Aktuelle Forschung in der Gartenbauökonomie – Thünen report 44, Braunschweig, pp. 21-39. Earlier version presented at: GEWISOLA 2017, 13.-15.9.2017, Technische Universität München, Germany AEL Doctoral Workshop, 27.-28.7.2018, Leibniz Universität Hannover, Germany 2. Symposium für Ökonomie im Gartenbau, 1.3.2016, Thünen-Institut, Braunschweig, Germany Tropentag 2015, 16.-18-9-2015, Humboldt-Universität zu Berlin, Germany
4	Nutrient-Dense Crops for Rural and Peri-Urban Smallholders in Kenya—A Regional Social Accounting Approach	Henning Krause, Anja Faße, Ulrike Grote	Published in: Sustainability 2019, 11, 3017 Earlier version presented at: Tropentag 2018, 17.-19.9.2018, Ghen University, Ghent, Belgium Congress FOOD 2030: Towards Sustainable Agri-

			food Systems, 5.-6.9.2018, University of Hohenheim, Stuttgart, Germany Tropentag 2017, 20.-22.9.2017, University of Bonn, Germany
5	Value Chains of African Indigenous Vegetables in Kenya – A Multi-Stakeholder Analysis	Sindu Workneh Kebede, Henning Krause	Submitted for publication: As chapter in the book "Crafting Knowledge for Sustainable Food Systems" Some results of this article are based on: Sindu Workneh Kebede, Henning Krause, Evans Ngenoh, Hillary Bett, Anja Faße, Wolfgang Bokelmann (2018): Hortinlea Baseline Survey Report 2014. Hannover Economic Papers No. 641

Notes:
The results presented in chapters 3 and 4 of this thesis are also included in the following two chapters of the book "Crafting Knowledge for Sustainable Food Systems":
Henning Krause, Sabina Khatri Karki, Anja Faße, Ulrike Grote (2019): Economic potential of commercial AIV production
Henning Krause, Sabina Khatri Karki, Anja Faße, Ulrike Grote (2019): The importance of AIV production for food security

Chapter 4 examines the food security and economic effects of horticulture production from a wider perspective by constructing a social accounting matrix (SAM) for areas of high-level AIV production in Kenya. The SAM was constructed based on 706 rural and periurban small-scale vegetable producers in Kenya, and secondary data were used to complement missing elements and validate the findings of the analysis. Households were clustered according to their level of food security following the FAO's definition of food security. The following research questions were answered: (1) How do livelihoods between household groups in AIV-producing areas with different levels of food security differ? (2) What crops have the highest indirect income effects on rural and periurban economies in AIV-producing areas? (3) What crops have the highest direct income effects on household groups with different levels of food security? The analysis showed a significantly higher prevalence of food insecurity in rural areas, especially in the utilization and stability dimensions of food security. Food-secure producers have higher levels of education, own more land, and have more income from off-farm employment and less income from crop production than food-insecure producers. AIVs have higher multiplier effects on the village economy than many cash crops, such as coffee, tea or maize. This is especially true for the less commonly produced AIVs, such as murenda, pumpkin leaves and enderema. Because of the nutritional benefits of AIVs and their effect on the regional economy, AIVs are suggested to further promote the production of AIVs in rural and periurban areas in Kenya.

Chapter 5 presents an analysis of the performance of AIV value chains using the Hortinlea panel survey undertaken in rural, periurban and urban areas in Kenya in 2014, 2015 and 2016 focusing on producers, traders and consumers of AIVs. The following research questions were answered: a) What are the

production practices of AIV farmers in the main areas in Kenya in which AIVs are produced? b) What are the specific marketing strategies used by those AIV producers? c) What socioeconomic determinants influence AIV producers' decision to adopt a certain marketing strategy? d) What challenges and opportunities for the AIV value chain are visible from the traders' and consumers' perspective? For these analyses, we applied descriptive statistics to samples of producers, traders and consumers. To answer research question c), an ordered probit was used. The results showed that for the most important AIVs African nightshade, cowpeas, spider plant and amaranth, a large number of varieties are produced in smaller quantities. The production of AIVs has increased over the last five years mainly through more intensive production techniques as opposed to an increase in the area under AIV cultivation. Approximately 80% of the producers sampled sell a certain amount of AIVs, but few producers sell a great proportion of their harvest, indicating a high level of commercialization. Most selling occurs in local markets at the village level without contracts and with limited packaging and postharvest handling. Of the producers that market their AIVs, most do individually, with higher rates of group marketing observed in Kakamega and Kisii. Wealthier households with young, male household heads and access to credit and modern irrigation techniques are more likely to market their AIVs in groups. In Nairobi, most AIVs are sold at open-air markets. Traders obtain their AIVs mainly from middlemen or wholesalers. Consumers in Nairobi prefer buying at open markets mostly because they are close to their homes and they have fresh vegetables for affordable prices. Trust in the safety of the vegetables is one of the major criteria with which consumers decide to remain with a specific AIV trader. One of the major problems for consumers in Nairobi is that AIVs are not available throughout the year for affordable prices, showing the need for irrigation and suitable storage facilities on the production and trade sides of the chain.

Author contributions to the papers are as follows: For chapter 2, Henning Krause generated the idea, participated in cleaning the data set, performed statistical analyses and wrote the paper. Rattiya Suddeephong Lippe contributed to shaping the ideas, provided the Heckman analysis as a robustness check, and revised drafts of the paper. For chapters 3 and 4, Henning Krause generated the idea, participated in collecting the data as part of the Hortinlea household survey 2015, cleaned the data set, performed statistical analyses and wrote the paper. Anja Fasse contributed to shaping the ideas, provided feedback on the methodology and revised drafts of the paper. Ulrike Grote contributed to chapters 2 – 4 by shaping the ideas, revising drafts and editing the final versions of the papers.

For chapter 5, Sindu Workneh Kebede participated in collecting the data as part of the Hortinlea household survey 2014, and Henning Krause cleaned the data set. Sindu Workneh Kebede and Henning Krause generated the idea, performed statistical analyses and wrote the paper.

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2. Adoption and Income Effects of Public GAP Standards: Evidence from the Horticultural Sector in Thailand

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3. Welfare and Food Security Effects of Commercializing African Indigenous Vegetables in Kenya

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4. Nutrient-dense Crops for Rural and Peri-urban Smallholders in Kenya – a Regional Social Accounting Approach

Henning Krause, Anja Faße, Ulrike Grote

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5. Value chains of African indigenous vegetables in Kenya – a multi-stakeholder analysis

Sindu Workneh Kebede and Henning Krause

5.1. Introduction

Horticulture is the fastest growing sector within the agricultural sector worldwide, contributing to poverty alleviation and nutritional security, offering income opportunities and generating huge employment opportunities along the value chain (Singh 2011; Joosten et al. 2015). In Kenya, fresh vegetables constitute a significant portion of the horticultural output, accounting for about 21 % of the horticultural export volumes in 2017 (Capital Business 2018). But as well domestic demand is rising: especially African indigenous vegetables have a high growth potential: area und AIV production increased of about 25 % from 2011 to 2013 because of the higher domestic demand for those vegetables (Cernansky 2015). Research studies reveal that in Kenya more than 210 species of leafy vegetables are part of traditional diets (IPGRI 2006). However, many of these crops are still underutilized with a great potential to be harnessed (Cernansky 2015).

In this chapter, we will thus focus on the following research questions:

1 What are the production practices of AIV farmers in the main AIV production areas in Kenya?
2 What are the specific marketing strategies of those AIV producers?
3 Which socio-economic determinants influence AIV producers' decision for a certain marketing strategy?
4 Which challenges and opportunities are visible for the AIV value chain from traders and consumers perspective?

5.2. Background

This chapter aims to analyze the performance of AIV value chains using the Hortinlea panel survey undertaken in rural and peri-urban areas of Kenya in 2014, 2015 and 2016. The rural sites were in two counties in Western Kenya: Kisii and Kakamega. The peri-urban sites were in the three counties Kiambu, Nakuru and Kajiado. The capital Nairobi is the urban site where traders and consumers were interviewed (Table 2 and Figure 1). Households in the producer survey were selected using multi-stage sampling approach. First the five counties were purposely selected based on prevalence of AIV

production. The selection of the sub-counties and divisions was based on information from the respective district agricultural offices. From each division, locations/wards were randomly selected, and in turn households within locations were randomly selected. For consumers and traders, the markets were purposely selected based on prevalence of AIV sales and traders on the markets and consumers in the surrounding area were selected following the snowball principle. This is an approach where we identify few potential respondents in the population and these respondents are requested to recruit other respondents, who will in turn recommend more respondents. These steps are repeated until the required sample size is achieved. The survey was carried out through face-to-face interviews with farmers, traders and consumers engaged in indigenous vegetable production, marketing, and consumption.

This chapter primarily uses the survey conducted in 2014 to assess the performance of AIV value chains. This is mainly because the 2014 survey provides baseline data to assess the performance of AIV value chain and examine its status quo. It is also the survey with the largest number of respondents from AIV producers, traders and consumers as compared to the other two rounds. However, close reference is also made to surveys in 2015 and 2016 to evaluate the change in AIV performance overtime. Kajiado County was excluded in the analysis, because the small sample size did not ensure representativeness and the county has not been included in the following years.

Table 2: Hortinlea panel survey locations and number of respondents

		2014	2015	2016
AIV producer Households	Kisii	401	201	199
	Kakamega	407	202	197
	Nakuru	221	151	145
	Kiambu	183	152	144
	Kajiado	20	-	-
	Sub-total	**1232**	**706**	**685**
AIV Traders	Nairobi	157	-	152
AIV consumers	Nairobi	154	-	150
Gross Total		**1543**	**706**	**987**

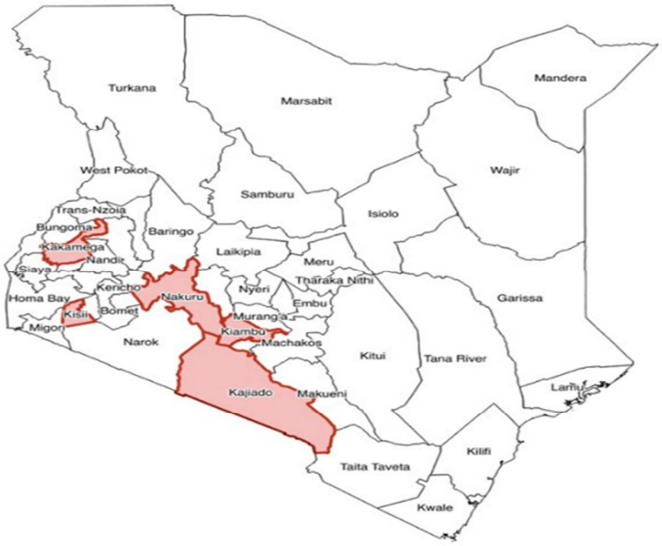

Figure 1: Hortinlea panel survey sites

An important note about Hortinlea survey is that it is not representative at a national level. However, the data provides a comprehensive overview of indigenous vegetable producers in rural and peri-urban areas and traders and consumers in urban areas. For AIV producers, given the randomized sampling method and the relatively large sample size in each county, results of analysis on the survey data can be generalized to indigenous vegetable producers in rural and peri-urban areas in Kenya. For AIV traders and consumers, due to a rather small sample size and purposive sampling method, analytical results for these groups of AIV actors should be taken as only indicative.

5.3. AIV Producers in Kenya

The most widely produced indigenous vegetables by farmers in our sample are African nightshade (*Solanum spp.*), cowpeas (*Vigna unguiculata*), spiderplant (*Cleome gynandra)* and amaranth (*Amaranthus spp.*). This is confirmed by previous findings, as those four AIVs are most important based on their economic and nutritional potential in Kenya, Tanzania and Uganda (Abukutsa-Onyango 2010) and are the most cultivated AIVs by small-scale vegetable producers in Eastern and Central Kenya (Mbugua et al. 2011). African nightshade is by far the most popular AIV produced by about 72 % of the respondents followed by cowpeas produced by 48 % (Table 3). Almost 60 % of the farmers in the sample produce two to three AIVs at the same time, while 11 % produce even four or more AIVs. About 21 % of the sample produces only one AIV and 8 %does not produce any AIVs at all.

AIV production seems to be evenly distributed across the regions. For instance, the highest percentage of farmers producing Amaranth is found in Kiambu County, while the highest percentage of Cowpea producer farmers is found in Kakamega County. African Night shade is widely produced in most of the counties, the highest being in Kiambu followed by Kisii and Kakamega. Nakuru County has the highest percentage of Spiderplant producer farmers from our sample survey. The average area allocated to the production of these indigenous vegetables is similar across the four species, the highest being 0.096 ha for spiderplant and the lowest 0.079 ha for African nightshade (Table 3). These indigenous vegetables have a long history of production in the different villages the survey took place. In some villages, AIVs were produced since as far back as the 1950s. However, more than 60 %of respondents started or increased their production from the year 2000 onward. Almost 30 % of the sample just started producing AIVs in 2010. One of the reasons could be that the creation of awareness on the benefits of AIVs to health and nutrition has triggered more households to start producing these vegetables.

Table 3: Share of producers producing AIVs in rural and peri-urban Kenya

	N	Amaranth	Cowpeas	African nightshade	Spiderplant
Kisii	401	44.9 %	30.2 %	74.6 %	53.4 %
Kakamega	407	38.8 %	86.0 %	72.2 %	37.3 %
Nakuru	221	14.0 %	37.6 %	59.7 %	57.5 %
Kiambu	183	67.8 %	10.4 %	78.1 %	23.0 %
Total	1212	40.7 %	47.3 %	71.6 %	44.1 %
Average crop area [ha]	1212	0.086	0.086	0.079	0.096

Source: Own data

The survey shows also that the increased production is not based on an increased production area, as the area planted with AIVs remained the same for all four indigenous vegetables compared to five years ago. Yield increases of three major AIVs excluding amaranth is reported by the majority of farmers. Respondents also report that yield increases are achieved above all through favorable weather conditions and soil fertility improvements. Yield increases could also point to agricultural intensification strategies. To analyze the notion of intensifying AIV production, intensification strategies in soil and water management and genetic intensification were further analyzed.

Table 4: Fertilizer, Seed and Irrigation use for AIV production [% of AIV cultivations of all AIV producers]

	Amaranth (N = 493)	Cowpeas (N = 573)	African nightshade (N = 868)	Spiderplant (N = 535)	All AIVs (N = 2538)
Household apply fertilizer to grow this product	79.1	78.5	85.3	87.3	82.7
How often did household put fertilizer to grow this product?					
Once in every season	50.8	62.2	56.4	61.9	47.4
Twice per season	21.0	19.1	21.1	20.8	17.0
More than twice per season	26.2	17.1	21.1	15.2	17.0
Type of fertilizer used by the household					
Inorganic	27.9	29.3	29.5	30.8	24.0
Organic	47.7	56.0	47.7	49.0	41.8
Both	22.3	14.0	22.2	18.8	16.2
Source of fertilizers					
On farm	42.1	51.6	43.4	45.4	38.0
Outside farm	30.8	31.1	31.5	32.5	25.7
Both	21.3	14.7	21.4	18.2	15.8
Seed use and source (Percentage of households)					
Household buy seeds to plant this product?	54.2	65.4	57.6	56.1	58.2
Types of seeds planted?					
Usual seeds/local	58.4	73.8	66.4	71.4	67.9
Improved	12.2	9.2	10.3	8.6	9.9
Certified improved	19.3	11.0	15.6	14.0	14.5
Organic	0.2	0.2	0.2	0.2	0.2
Source of Seeds					
Within the village	63.5	66.5	66.1	69.0	66.4
Outside the village but within the region	17.4	21.6	19.4	17.2	18.8
Outside the village but within Kenya	2.2	1.0	2.2	2.8	2.0
Irrigation use (Percentage of households)					
Household use irrigation to grow AIV	20.1	8.6	18.3	12.9	14.9
Reason for not using irrigation					
No need	71.1	65.1	63.5	56.2	54.0
Shortage of money	3.0	11.1	9.6	10.9	7.9
Shortage of water	5.3	8.6	8.6	12.2	7.3
Others	0.5	1.5	2.1	1.5	1.4

Source: Own data

Most respondents have developed soil fertility strategies and apply fertilizer for growing AIVs, ranging from 79 to 87 % of the sample (Table 4). Of the farmers that use fertilizer, the majority applies them just

once in every season and half of them use organic fertilizers from their own farm to grow these vegetables. Another 30 % of the producers use inorganic fertilizers. However, the use of inorganic fertilizer might not be entirely due to AIV production alone. Most AIVs are intercropped with other crops such as maize which implies that the inorganic fertilizer might have been applied to the intercropped product and not necessarily to AIVs exclusively. A smaller part of the sample uses an integrated soil fertility strategy by applying both organic and inorganic fertilizers for AIV production.

The majority of the producers use usual/local seeds to grow AIVs ranging between 58 - 74 % depending on the specific AIV, while improved, certified or organic seeds are used by about a quarter of the sample. Around 66 % of the producers buy their AIV seeds from sources within the village. We find that less than 15 % of the respondents use irrigation to grow AIVs. The crops with the highest share of irrigation are amaranth and African nightshade. Asked for the reasons why farmers do not irrigate their AIVs, the majority of respondents reported that there is no need for irrigation to grow these vegetables. Some also mention shortage of water and shortage of money as main reasons for not using irrigation.

5.3.1. Market outlets for AIV producers

About 78 % of the sampled households sell their AIV produce (Figure 2). African nightshade is the most marketed AIV in rural areas while in peri-urban areas, both amaranth and African nightshade stand as the most marketed ones. We found that most producers do not have contract with buyers. Less than 30 % of amaranth and African nightshade producers have a contract and the ratio is even lower for other AIVs in rural areas. In peri-urban areas the share of producers that sell AIVs under contract farming with buyers is highest, especially for Amaranth, but similarly for African nightshade and cowpea.

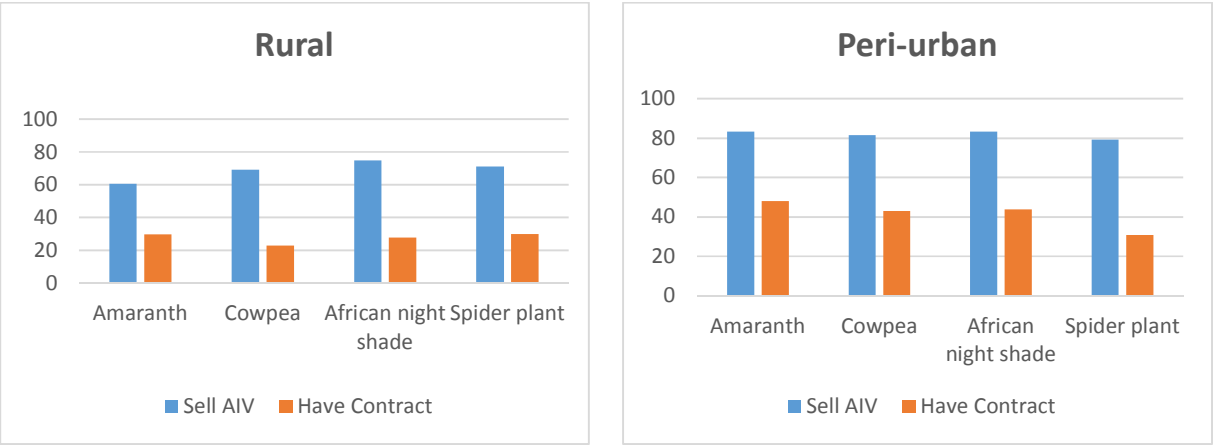

Figure 2: Marketing of AIVs [% of households]. **Source:** Own data

Most producers in rural areas directly sell their produce to consumers while some sell to middlemen (Table 5). In peri-urban areas, AIV producers sell AIVs mostly to middlemen and retailers. Sell of AIVs to supermarkets is limited to less than two percent of respondents, the highest being amaranth followed by African nightshade and cowpea in both rural and peri-urban areas. This shows that the value chain from producers to high-value markets such as supermarkets is not well developed for the AIVs. It could also be the case that the middlemen or wholesalers are the ones who bridge the gap between the producers and supermarkets. Export of AIVs is quite rare among the sampled producers. Most producers rather sell their produce within the village while more than 30 % sell within the county.

Table 5: Marketing of AIVs [% of households that sell their AIVs]

	Rural Counties				Peri-Urban Counties			
	Am (N =378)	**Cp (N =509)**	**An (N =624)**	**Sp (N =405)**	**Am (N =173)**	**Cp (N =114)**	**An (N =282)**	**Sp (N =184)**
To whom do you sell your produce?								
Supermarkets	3.06	0.85	1.28	1.39	4.17	2.15	2.55	1.37
Wholesalers	0.44	0.57	0.64	1.39	17.36	16.13	14.89	13.70
Retailers	2.62	5.11	3.64	2.08	32.64	40.86	34.47	39.04
Consumer	79.04	79.55	80.51	77.78	7.64	19.35	17.02	24.66
Export	0.00	0.28	0.21	0.35	0.00	0.00	0.00	0.00
Middlemen	14.41	13.35	13.70	16.32	37.50	20.43	31.06	20.55
Processor/ manufacturer	0.44	0.28	0.00	0.69	0.69	1.08	0.00	0.68
Where do you sell your produce?								
Within the village	51.53	58.24	59.10	61.46	63.19	77.42	68.09	72.60
Outside village but within the county	46.72	40.06	39.19	38.19	22.92	17.20	22.13	17.81
Outside the county but within Kenya	0.87	0.57	0.64	0.00	13.19	5.38	9.79	9.59
Outside Kenya	0.87	1.14	1.07	0.35	0.69	0.00	0.00	0.00
Post-harvest handling								
Grading and sorting	42.36	45.45	46.90	54.51	54.17	46.24	50.21	43.84
Washing	31.88	38.35	34.90	37.50	25.69	13.98	19.15	20.55
Packaging								
Woven/gunny bag	50.21	59.95	56.53	52.78	25.7	22.58	21.28	18.49
Plastic bag	26.20	21.59	24.20	28.13	2.78	4.30	8.09	6.85
Wooden/plastic crate	4.37	3.41	3.85	3.82	1.39	2.15	0.85	2.05
No packaging	19.22	15.05	15.42	15.27	70.13	70.97	69.78	72.61

Source: Own data
Notes: Am = Amaranth, Cp = cowpea, An = African nightshade, Sp = Spiderplant

Regarding postharvest handling, more than 40 % of the AIV producers reported to sort or grade their produce. The sorting or grading is conducted according to size in all AIVs. Other criteria include blemishes (for amaranth, cowpeas and African nightshade) and weight (for African nightshade and spiderplant). Some AIV producers also wash their products after harvest. More than half of the producers package their produce after harvest. For this, they mainly use woven or gunny bags especially

in rural areas, whereas plastic bags or crates are used less often especially in peri-urban areas. The effect of using different packaging system is now widely studied (Onyango and Imungi 2007; Nyaura et al. 2014; Gogo et al. 2016; Sehrawat et al. 2018). Given that AIVs are perishable products with short shelf-life, advanced post-harvest handling and processing is essential to ensure freshness and good quality, reduce losses and better benefit from good prices.

The survey reveals that women play the major role in production and marketing of AIVs. Almost 60 % of the producers stated that women are responsible for producing AIVs and in about 57 % of the sample women are also responsible for marketing (Figure 3). If women are responsible for marketing AIVs, they have in almost 90 % of the cases also control over the income generated by those sales. However, the share of income from AIVs on the overall household income is 9.4 % which is rather small. If there are no other income sources, women are left with a relatively small budget for spending according to their own needs. Likewise, earlier studies confirm, that AIVs are still considered a subsistence crop in Kenya, and are traditionally considered a "women's crop". On the contrary, there are other trends in urban areas where it was found that the proportion of men in AIV production is significantly higher than in rural areas. It is mainly attributed to the shift in perception that AIVs have the potential to be a viable cash crop (Weinberger and Pichop 2009). Our data suggest that this development has not yet spilled over to the peri-urban and rural areas in Kenya.

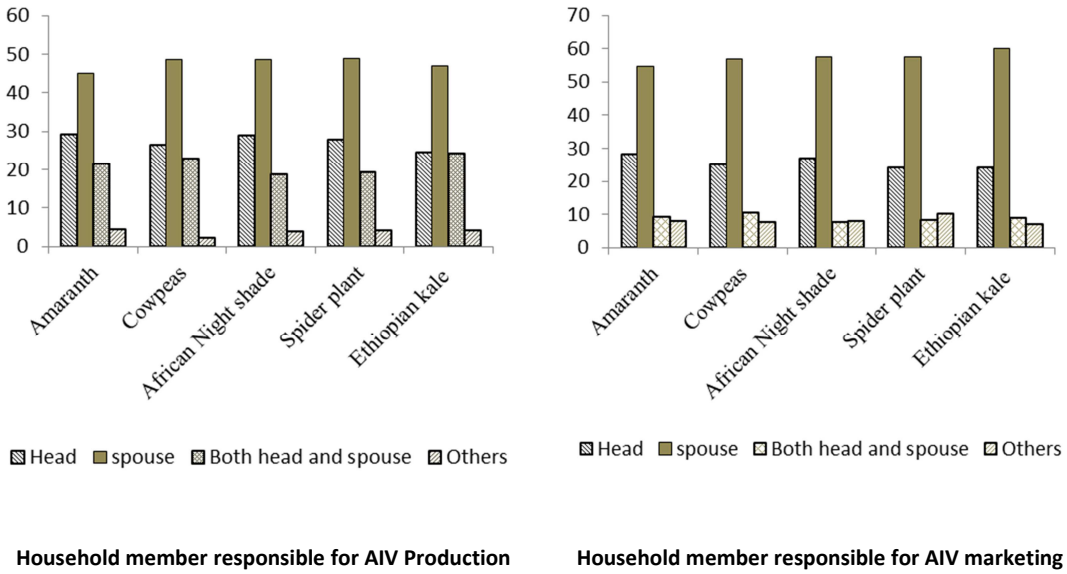

Figure 3: Household members responsible for AIV production and marketing **Source:** Own data

5.3.2. AIV producers categories

With regard to their value chain strategies AIV producers can be broadly classified into three groups. 1) Those who do not sell their AIV products and only use it for home consumption – "subsistence AIV producers" (26 % of sampled producers); 2) those who sell their AIV products individually – "commercial AIV producers not organized in groups" (46 % of sampled producers) and 3) those who sell their AIV products and are organized in farmer group – "commercial AIV producers organized in groups" (28 % of sampled producers).

Of the commercial AIV producers organized in groups, about 92 % of them reported that the main benefit of the group was the empowerment of the members in production and marketing activities of AIVs. In terms of marketing, about 81 % of farmers reported that the group has a marketing agreement with the vegetable buyer even though majority of farmers organized in groups reported to be free to choose to whom they sell their vegetables. This is confirmed by the fact that even if AIV farmers are members of a farmer group dealing with vegetables, the majority of them could still be selling their produces individually. Of course, a significant amount of farmers (about 59 %) sell AIVs as a group where the product is taken to a central place where buyers collect it. In some cases, members bring products together and the group leader looks for a buyer. From commercial AIV producers organized in groups, about 90 % reported to have written down rules and regulations in their groups which are usually enforced by officials. The major focus AIV species of farmer groups on vegetables is African nightshade, which has as well the highest production share among the AIVs in our sample. Amaranth and cowpeas are also given due focus in the farmer groups. About 41 % of the AIV producers organized in groups reported that better prices are the first most important advantage obtained from engaging in vegetable farmer groups. Some also mentioned that they can focus on production since markets are ensured through the vegetable groups and others mentioned that all produce is sold and nothing is wasted. Therefore, AIV producers organized in groups benefit in the aforementioned way as compared to those commercial AIV producers not organized in groups.

Kakamega County reported the highest proportion of farmers organized in groups (62 %), followed by Kisii County with about 39 % of the surveyed farmers organized in groups (Figure 4). These differences were statistically different across the surveyed counties. The high proportion of farmers belonging to a group in Kakamega could partly be explained by the fact that many farmers are already members of cooperatives in the County. Even after considering this small bias, we still find farmers groups play a major role in Kakamega County via providing production and market information, linking farmers to

important input and output market outlets, and mobilizing savings and credit in rural areas where formal savings and credit institutions like banks might be lacking.

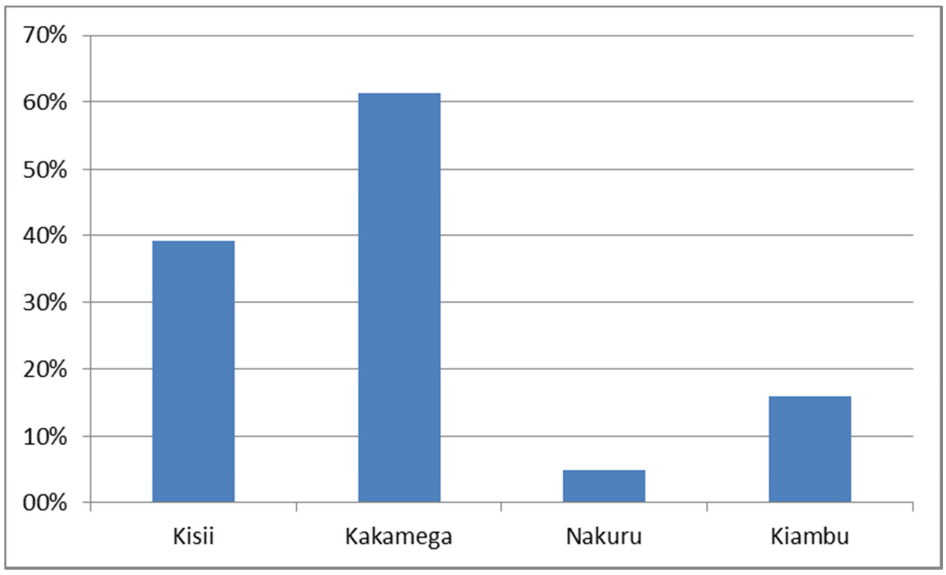

Figure 4: Membership to a farmer group dealing with vegetables [% of Households]
Source: Own data; **Notes:** N = 1212

Further analysis on group composition revealed that the average number of members in a group was 21 with the smallest groups in Nakuru (17 members) and the largest one in Kakamega (22 members). About 70 % of the group members are female, which could be an indication that there is a higher collective action among women than men. With 95 %, Nakuru County had the highest proportion of females belonging to groups while Kakamega had the lowest (69 %).

Given the above advantages of engaging in a farmer group, it is worth exploring the socio-economic factors that cause AIV producers to sell their AIV produces in groups as compared to those who are not members of a group (hence sell individually) and those who do not sell AIVs (are subsistence producers). For this, we use an econometric model as described in the paragraph below.

Socio-economic determinants of AIV producer categories: we would like to further explore what are the socio-economic determinants for AIV producers to fall into one of the aforementioned three AIV producer categories. Investigation of these important benchmark variables helps to better understand the farming systems of AIV producers as well as design better targeted strategies for greater impacts to each group of producers in AIV production and marketing. An important procedure to identify the proper econometric model is to distinguish if there is a logical order of the alternative categories namely, whether selling AIVs through organized groups is better than selling AIVs individually. There is a

wide consensus in the literature on collective action and farmer organizations that collective action is advantageous to smallholder marketing by reducing transaction costs and filling coordination gaps (Devaux et al. 2009; Hellin et al. 2009; Markelova et al. 2009; Fischer and Qaim 2012). Farmers are able to obtain necessary information when they are organized in groups and can sell to distant markets. Moreover, the benefits of farmer organizations are more evident in short shelf-life produce like the vegetable sector, which is characterized by high transaction costs associated with market access (Hellin et al. 2009). This empirical evidence suggests the existence of a logical order of classification that calls for use of the ordered probit model (Wooldridge, 2010). Here, dependent variable Y_i is logically ordered (1 to 3) by category, in our case: 1) subsistence AIV producers; 2) commercial AIV producers not organized in groups and 3) commercial AIV producers organized in groups[1]. Since the objective here is to identify factors that influence marketing of AIVs within groups (3), as compared to producing for subsistence (1) or selling them individually (2), the logical ordering of the dependent variable is designed in such a way that the highest value was assigned to farmers who sell their AIV products in groups. However, due to lack of evidence on the benefit of farmer groups on AIV marketing specifically, we also run a multivariate probit model, which simultaneously estimates socio-economic determinants of AIV marketing in groups (see table 3.1 in Annex). The multivariate model estimation results are used as a robustness check.

In the ordered probit model, the modalities of the dependent variable Y_i were:

$$\begin{cases} Y_i = 1\ (if\ hh\ produces\ AIVs\ but\ donot\ sell\ them) if Y_i^* < C1 \\ Y_i = 2\ (if\ hh\ produces\ AIVs\ individually\ and\ sells) if C_1 \leq Y_i^* < C_2 \\ Y_i = 3\ (if\ hh\ sells\ AIVs\ and\ is\ organised\ in\ groups) if C_2 < Y_i^* \end{cases}$$

The ordered probit model is described as:

$$Y_i^* = X_i\beta + u_i \quad (1)$$

Where X_i is a vector of explanatory variables, β is a vector of the associated coefficients and u_i is a random component. In the model, an underlying score was estimated as a linear function of the set of independent variables and a set of cut points C_i. The probability of observing outcome *i* corresponds to the probability that the estimated linear function, plus random error, is within the range of the cut points estimated for the outcome:

$$Pr(Outcome_j = i) = \Pr(C_{i-1} < X_i\beta + u_i \leq C_i) \quad (2)$$

[1] Households who do not produce any of the AIVs, about 64 households, are excluded from the econometric analysis.

The marginal probabilities could therefore be calculated from the probit model as:

$$\frac{dprob[Y_k]}{dX_k} = [\varphi(C_{i-1} - \beta' X_i) - \varphi(C_i - \beta' X_i)]\beta \quad (3)$$

Where $\varphi(.)$ is the normal density is function and C_i is the threshold parameter.

The explanatory variables included in the model were categorized into household characteristics (including the age of the head of the household, gender of the head of the household), household wealth status (household consumption expenditure, off-farm income as occupation of household head), household opportunity for diversified income source (such as remittances), distance to market, access to market information, and County dummy. A summary of the independent variables used is given in Table 6.

Before discussing the econometric results, we describe the independent variables in comparison to the three categories of households. The mean age of household head is almost the same for all three categories of households while the mean consumption expenditure per capita varies significantly among these categories. It is found that those who sell AIVs individually have higher consumption expenditure per capita, a variable capturing welfare of households. Those households who sell in groups have the highest average AIV production per year. This could imply that a higher production encourages AIV producers to join groups which also facilitates easy and rapid sale of AIV harvests.

The highest percentage of households from rural areas and those that are male headed households are also members of groups that facilitate the sale of AIV products. However, a higher percentage of households with off-farm income as their main occupation tend to sell their AIVs individually as well as those with access to market information and those who use modern irrigation[2]. It is evident from the descriptive results that a higher percentage of households who grade their AIV products tend to rather sell AIVs within groups and the same is true for those households who received remittances. We further explore these relationships deeply using ordered probit models.

[2] Modern types of irrigation systems include drip, sprinkler and pot irrigation methods. This is in contrast to traditional irrigation types which include basin, furrow and strip irrigation methods.

Table 6: Summary of independent variables used in the ordered probit model

	Subsistence AIV producers	Commercial AIV producers not organized in groups	Commercial AIV producers organized in groups
Percentage of households	25.67	46.33	28.00
Mean, age of head of hhs	50.84	49.85	49.00
	(13.35)	(12.88)	(11.43)
Mean, household size	5.64	5.34	6.04
	(2.10)	(2.30)	(2.40)
Mean, household head years of schooling	9.78	9.42	9.14
	(4.96)	(4.51)	(4.30)
Mean, total consumption per month per capita (USD)	47.28	63.31	47.42
	(45.98)	(53.24)	(40.25)
Mean, total AIV production per year in kg	1284	2092	2232
	(2468)	(3652)	(3676)
Mean, land size in hectare	0.81	1.04	0.82
	(0.9415)	(2.912)	(0.9455)
Mean, distance to markets (km)	2.12	2.55	2.26
	(2.5730)	(2.523)	(2.360)
Variables	**Percentage of households**		
Households living in rural locations	74.07	46.08	88.89
	(0.4389)	(0.4989)	(0.3147)
Male headed households	81.82	77.43	84.26
	(0.3863)	(0.4184)	(0.3647)
Married households	83.50	76.49	83.33
	(0.3717)	(0.4244)	(0.3732)
Head with off-farm income as main occupation	24.58	35.45	21.30
	(0.4312)	(0.4788)	(0.4100)
Household owns farm land	88.89	88.81	89.81
	(0.3148)	(0.3155)	(0.3029)
Household has access to credit	13.13	19.96	22.53
	(0.3383)	(0.4000)	(0.4184)
Household has access to market information	30.30	41.23	38.58
	(0.4603)	(0.4927)	(0.4875)
Household with access to modern irrigation	10.10	20.90	13.27
	(0.3018)	(0.4069)	(0.3397)
Household grade AIVs before taking to markets	22.56	41.60	43.83
	(0.4186)	(0.4933)	(0.4969)
Household received remittance in past 12 months	24.05	33.88	38.01
	(0.4281)	(0.4738)	(0.4862)

Source: Own data
Notes: Standard deviation in brackets

The maximum likelihood estimates of the parameters of the ordered probit model for the different categories of households are shown in Table 7 in column (1) and (2). From the household head characteristics, we find that age, education and gender of household head play significant role in selling AIVs in general and selling in farmer groups in particular. Households with older heads are less likely to be involved in marketing of their AIV products and also less likely to engage with farmer groups. Similarly, households with educated heads are less likely to sell AIVs organized in groups. This could because farmer groups provide the necessary protection and outlet which the less educated producers take advantage of while heads with higher level of education are able to sell AIVs individually. In

contrast, male headed households are more likely to sell their AIV products in farmer groups. This result does not contradict with the finding that women play the major role in AIV production and marketing. This is because most of the male headed households are married households (about 95%) where the spouse takes the major role in becoming member of vegetable group in which way she takes the lead role in AIV production and marketing.

From the list of variables used to capture the level of welfare of households, we found that total consumption expenditure plays a significant and positive role in marketing of AIVs in general and AIV marketing in groups in particular. This implies that better-off AIV producers sell their AIVs especially within farmer groups that benefit them in terms of price and better access to buyers. This result is consistent also with AIV producers who have received remittance in the past 12 months. Those AIV producers have a higher likelihood of selling their AIV products. This variable is consistently positive and significant both in selling AIVs in groups as well as selling AIVs in general (as shown in Table A1 in Annex). This is because remittances boost households' income and hence encourages AIV producers to take the necessary step to market their AIV products whether it is grading, packaging or engaging in vegetable farmer group activities.

Important policy variables such as access to credit, market information and modern irrigation are also found to play a significant role in promoting marketing of AIVs as well as selling via farmer groups. Market information is important for farmers in terms of assessing the price of AIVs that enables producers decide when to sell and where to sell their products. Access to modern irrigation is found to increase the likelihood of selling in groups, as modern irrigation enhances production which in turn allows producers to attain good harvest for markets.

Table 7: Socio-econometric determinants of AIV marketing in farmer groups

Variables	**Model I:** **AIV marketing**	**Model II*:** **AIV marketing**
Age of head of HH	-0.00978***	-0.00948***
	(0.00300)	(0.00299)
male HH head	0.224*	0.227*
	(0.123)	(0.123)
Household size	0.0257	0.0252
	(0.0197)	(0.0196)
Married	-0.213*	-0.192
	(0.122)	(0.122)
Years of education of HH head	-0.0149*	-0.0156*
	(0.00904)	(0.00910)
Household welfare indicators		
Land size in ha (in log)	0.0171	0.0183
	(0.0333)	(0.0334)
Household owns land	0.135	0.126
	(0.117)	(0.117)
Total consumption expenditure (in log)	0.198***	0.194***
	(0.0577)	(0.0575)
Off-farm income	0.0304	0.0245
	(0.0774)	(0.0774)
Remittances	0.224***	0.253***
	(0.0766)	(0.0761)
Access to services		
Credit	0.251***	0.253***
	(0.0906)	(0.0898)
Market information	0.117	0.0988
	(0.0782)	(0.0778)
Modern irrigation	0.160	0.174*
	(0.0981)	(0.0985)
AIV Characteristics		
Total AIV production (in log)	0.0812***	0.0831***
	(0.0218)	(0.0214)
Grading of AIVs	0.343***	
	(0.0714)	
Location		
Distance to market (in log)	0.0828	0.0822
	(0.0522)	(0.0519)
Hhs from Kisii	0.0318	0.0292
	(0.114)	(0.114)
Hhs from Kakamega	0.379***	0.366***
	(0.118)	(0.117)
Hhs from Nakuru	-0.429***	-0.411***
	(0.0849)	(0.0827)
Prob>chi^2	0.0000	0.0000
Wald chi^2	133.57	122.64
Observations	1,019	1,019

Source: Own data

Notes: Dependent variable: AIV marketing = 1 if hhs do not sell AIVs, =2 if hhs sell AIVs individually, =3 if hhs sells AIVs organized in groups; Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; *The difference between Model I and II is that Model II excludes one explanatory variable namely 'Grading of AIV'. Since, farmers grade AIVs for marketing purposes, it could raise an issue of endogeneity. Hence, we estimate Model II without this variable for robustness purpose. We find more or less similar results.

In terms of AIV characteristics, the result shows that households that produce higher amount of AIVs tend to sell their products with a higher likelihood of selling them in farmer groups. This confirms the idea that selling a bulk of outputs in groups seems to be efficient to AIV producers. Also, those AIV producers who grade their products before marketing are more likely to sell their AIVs in farmer groups. This is an important procedure in marketing AIVs. As shown in section 3.2.1, about 40-50 % of AIV producers grade or sort their AIVs before taking them to markets. We note here that, the relation between grading and marketing could be endogenous. AIV producers could grade the AIVs because they need this procedure to market individually and/or in groups and it could also be a regulation in their group. To get around this problem, we estimate the ordered probit model excluding the variable 'grading of AIVs' as independent variable in the model, as shown in column (2) of Table 7. The results in column (1) and (2) are robust, where the level of significance of independent variables is more or less the same in column (1) and (2).

Location is found to play a significant role in marketing of AIVs. To capture this, we included the variable distance of market (in km). We found that households that live far from market places tend to sell their AIVs through farmer groups. Next to distance to markets, the region where households are located plays a role as well. AIV producers from rural counties such as Kisii and Kakamega (significant at 1% level) are found to sell in groups as compared to AIV producers in Kiambu County (which is our control county). AIV producers from peri-urban county Nakuru are less likely to sell their AIVs in groups as compared to those in Kiambu County.

5.4. AIV traders: market outlets

In terms of marketing of AIVs in Nairobi, the most important AIV is found to be African nightshade traded by about 62 % of traders in the sample followed by cowpeas. The reason for African nightshade to be the most important for traders is that it is highly demanded and highly profitable. About 87.8 % of traders reported that they use local open-air market (local shops at open markets or local market vendors) as their main channel of trade for AIVs. The average number of years a trader trades with AIVs is about eight years, the minimum being less than a year to a maximum of 60 years.

The market channels of AIV traders are shown in Table 8. Most traders (47 %) source AIVs from middlemen outside of the market they operate in but from within the same county. About 36 % also source AIVs from outside of their county. The majority of traders travel to middlemen to source the AIVs. Others access from local market vendors. In only 16 % of the cases, traders reported that

middlemen bring AIVs to them. Traders used vehicles such as pickup and lorry to transport AIVs from their source to selling points. In very few cases, manpower as a mode of AIV transport is reported.

The selling outlets of AIV traders are usually local shops at open markets, reported by about 70 % of traders. The second major market outlet is local market vendors, reported by 15 % of traders. Only about 2.5 % of traders sell to supermarkets and 3.8 % of them sell to hotels and restaurants. Traders rate the quality of AIVs they buy and sell as very good and good.

Table 8: Channels of AIV trading for AIV traders [% of traders]

Traders sourcing outlets of AIVs		**Traders selling outlets of AIVs**	
Source of AIV for traders		**Where do traders sell AIVs**	
Within sub-market	3.18	Within sub-market	17.83
Within market	9.55	Within market	70.70
Outside of market	35.67	Outside of market	5.73
Outside market but within county	46.50	Outside market but within county	2.53
Others	5,09	Others	3,19
Specific buying place of AIVs		**Specific selling place of AIVs**	
Local shops	2.55	Local shops at open markets	69.43
Trader travels to Middlemen	45.86	Supermarkets	2.55
Middlemen bring to trader	15.92	Middlemen	5.73
Local market vendors	31.85	Local market vendors	15.25
Others	3.82	Hotel and restaurants	3.82
		Others	3.19

Source: Own data; **Notes:** N = 157

5.5. AIV consumers: Market outlets

Among AIV consumers, the major AIV consumed is African nightshade reported by about 27 % of consumers followed by amaranth and cowpea, both reported by 23 % of consumers (Table 7). About 2 out of 3 consumers reported that it is the woman in the household buying the AIVs. Most consumers buy AIVs from local market vendors which are usually at open markets. Consumers prefer buying at the local open market vendor mostly because these are cheaper, nearer and have fresh vegetables. About 55 % of consumers responded that they have regular seller in the market where they buy AIVs, where more than 60 % of them reported that they trust their regular seller in terms of good quality, fair price, and good quantity. About 75 % of consumers rate the price of AIVs as higher than other exotic vegetables, even though most still say that prices are affordable. About 72 % of consumers actually reported that they would buy more AIVs if their prices are made cheaper. Nevertheless, most AIV consumers reported that they are satisfied with their AIV seller where purchasing of AIVS is quite easy.

Most AIV selling markets open early morning hours and few go until late morning hours or are open all day.

Almost 80 % of consumers disagree or strongly disagree that AIVs are available throughout the year. This shows the shortage of AIV supply throughout the year, which brings the notion of seasonality in AIV production as well as their perishable characteristics and lack of suitable storage. In addition, more than 85 % of consumers have the opinion that selling of AIVs in supermarkets leads to its scarcity in rural markets. Almost all consumers are found to cook and consume AIVs at home. Most consumers obtained information about AIVs from relatives and family members and they mostly consume AIVs because of their nutritional benefits.

Table 9: Channels of AIV purchasing for AIV consumers [% of households]

	Am	**Cp**	**An**	**Sp**	**Ek**
Share of households that consume (…)	23.8	23.2	27.2	14.8	11.2
Where do you buy AIVs from?					
No specific seller			20.55		
Wholesaler			9.68		
Retailer			6.52		
Local market vendor			56.52		
Individual producer			3.16		
Middlemen			0.40		
Contracted producers			3.16		
Why do you prefer this source of AIV?					
Cheaper			30.83		
Nearer			29.05		
Reliable			7.31		
Convenient			6.13		
Has fresh vegetables			21.94		
Availability of diverse AIV types			3.16		
Availability of AIVs throughout the year					
Strongly agree			13.64		
Agree			3.25		
Neutral/undecided			5.19		
Disagree			44.16		
Strongly disagree			33.77		

Source: Own data
Notes: Am = Amaranth, Cp = cowpea, An = African nightshade, Sp = Spiderplant, Ek = Ethiopian kale

5.6. Summary

The horticultural sector plays a significant role in the Kenyan economy with a rising demand on the domestic market and emerging opportunities for export. Therefore, strengthening the horticultural sector in general, and the production of African indigenous vegetables (AIVs) in particular, has the potential to address pressing challenges of undernutrition, poverty and sustainability among vulnerable people in rural and urban areas of Kenya. Using the Hortinlea household survey, this chapter analyzed the performance of AIV value chain considering AIV producers, traders and consumers in rural, peri-urban and urban locations.

We found that most of the AIV production is concentrated in rural areas of Kisii and Kakamega County and African nightshade has a wide coverage in terms of production, marketing and consumption. Most households sell their AIV produce directly to consumers at local open markets. Some also sell to middlemen and retails, however, they do not have contract with the buyer. Most farmers who sell their AIVs do so individually, a smaller share of farmers are organized in groups to market AIVs. However, in rural areas such as Kakamega County, we found the highest proportion of farmers selling AIVs in groups. Important policy variables such as access to credit, market information and modern irrigation are identified as playing a significant role in promoting marketing of AIVs in general and selling AIVs via farmer groups in particular.

Most traders use local open-air market as their main channel of trade for AIVs. Similarly, most consumers buy AIVs from local market vendors which are usually at open markets. Hence, local open markets seem to be the most viable channel of AIV marketing for producers, traders and consumers. To conclude, the performance of the AIV value chain has many opportunities to improve. Especially improving the marketing channels from producers to retailers and consumers could be further expanded and formalized (via contracts) so that producers could benefit from marketing of AIV products.

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Appendix

Table A1: Socio-econometric determinants of AIV marketing and AIV marketing in groups – multivariate model

	AIV marketing (1)		**AIV marketing in group (2)**	
Age of HH head	-0.0124***	(0.0038)	-0.00830**	(0.0036)
HH head is male	0.143	(0.165)	0.318*	(0.168)
Household size	0.0480**	(0.0238)	0.00231	(0.022)
HH head is married	-0.313*	(0.17)	-0.2	(0.166)
Years of education of HH head	-0.0252**	(0.0116)	-0.00548	(0.011)
Household welfare indicators				
Land size in ha (in log)	0.0282	(0.0469)	0.0274	(0.0443)
Household owns land	0.0859	(0.161)	0.141	(0.143)
Total consumption expenditure (in log)	0.267***	(0.0749)	0.128*	(0.0725)
HH head has off-farm occupation	0.189*	(0.11)		
HH received remittances	0.235**	(0.105)	0.189**	(0.0913)
Access to services				
Hhs has access to credit	0.189	(0.131)	0.314***	(0.111)
Hhs has access to market information	0.0962	(0.102)	0.182*	(0.0927)
HH has access to modern irrigation	0.175	(0.154)	0.325**	(0.134)
AIV Characteristics				
Total AIV Production (in log)	0.146***	(0.0252)	0.0203	(0.0242)
Hhs grades AIVs before selling	0.483***	(0.101)	0.139	(0.0871)
Location				
Distance to market (in log)			0.0691	(0.0626)
HH from Kisii	-0.953***	(0.194)	0.755***	(0.157)
HH from Kakamega	0.860***	(0.195)	1.288***	(0.16)
HH from Nakuru	-0.956***	(0.194)	-0.521***	(0.18)
Constant	-0.119	(0.469)	-1.955***	(0.458)
Prob>chi^2	0.000			
Wald chi^2	305.35			
Observations	1,019			

Source: Own data

Notes: Dependent variable: Model (1) AIV marketing =1 if hhs sell any one of AIVs, =0 otherwise, Model (2) AIV marketing in group =1 if hhs organized in groups, =0 otherwise; Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1