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Master Thesis

Women and African Leafy Vegetables (ALVs): The Informal Seed System in Vihiga County, Kenya

Submitted by

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Affidavit

I hereby declare that I have authored this master thesis independently, and that I have not used any assistance other than that which is permitted. The work contained herein is my own except where explicitly stated otherwise. All ideas taken in wording or in basic content from unpublished sources or from published literature are duly identified and cited, and the precise references included.

I further declare that this master thesis has not been submitted, in whole or in part, in the same or a similar form, to any other educational institution as part of the requirements for an academic degree.

I hereby confirm that I am familiar with the standards of Scientific Integrity and with the guidelines of Good Scientific Practice, and that this work fully complies with these standards and guidelines.

Vienna, May 2022 Anna-Sophie WILD *(manu propria)*

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Abstract

Wild, Anna-Sophie. 2022. Women and African Leafy Vegetables (ALVs): The Informal Seed System in Vihiga County, Kenya. Master thesis at the University of Natural Resources and Life Sciences Vienna (Austria).

African Leafy Vegetables (ALVs) play an important role for food sovereignty and nutritional security, with women central in the cultivation of ALVs on smallholder farms in Kenya. However, the main constraint of ALV cultivation in Kenya is the lack of available and accessible quality seeds. The aims of this thesis are to (1) identify which ALVs are cultivated and which factors influence cultivation, (2) to identify the sources of ALV seeds and which factors influence the informal seed system, and finally to (3) describe and analyze the extent in which women participate in and make decisions about the cultivation of ALVs. To fulfill these aims, data was taken from a 2018 baseline survey of 431 households in Vihiga County, located in the Lake Victoria Basin in Western Kenya. Over 88% of smallholder farmers in Vihiga County cultivate up to ten different ALV species, with over 90% of seeds stemming from three informal seed sources: the local market, own seeds, and farmer-to-farmer exchanges. Women are key actors in the cultivation of ALVs, more often responsible for ALV cultivation than men and more likely to cultivate ALVs. Women make most of the decisions regarding cultivation, sale and income through ALVs and are the central custodians in the ALV seed system. Understanding gendered intrahousehold dynamics and the gendered informal seed system of ALVs is essential for supporting ALV cultivation, ALV community seed bank initiatives and on-farm ALV seed conservation projects.

Kurzzusammenfassung

Wild, Anna-Sophie. 2022. Frauen und Afrikanisches Blattgemüse (ALVs): Das informelle Saatgutsystem in Vihiga County, Kenya. Masterarbeit an der Universität für Bodenkultur Wien.

Afrikanisches Blattgemüse (ALVs) spielt eine wichtige Rolle für Ernährungssouveränität und Ernährungssicherheit. Frauen sind zentral beim Anbau von ALVs in kleinbäuerlichen Betrieben in Kenia. Das Haupthindernis für den ALV-Anbau in Kenia ist jedoch der Mangel an verfügbarem und zugänglichem Qualitätssaatgut. Ziel dieser Arbeit ist es, (1) herauszufinden, welche ALVs angebaut werden und welche Faktoren den Anbau beeinflussen, (2) die Quellen von ALV-Saatgut zu identifizieren und welche Faktoren das informelle Saatgutsystem beeinflussen, und schließlich (3) zu beschreiben und zu analysieren, in welchem Umfang Frauen am Anbau von ALVs teilnehmen und Entscheidungen darüber treffen. Um diese Ziele zu erreichen wurden Daten aus einer 2018 durchgeführten Basiserhebung in 431 Haushalten im Bezirk Vihiga im Viktoriasee-Becken in Westkenia verwendet. Mehr als 88% der Kleinbäuer:innen im Bezirk Vihiga bauen bis zu zehn verschiedene ALV-Arten an, und mehr als 90% des Saatguts stammen aus drei informellen Saatgutquellen: dem lokalen Markt, eigenem Saatgut und dem Austausch zwischen Bäuer:innen. Frauen sind die Hauptakteure beim Anbau von ALVs, da sie häufiger für den ALV-Anbau verantwortlich sind und häufiger ALVs anbauen. Frauen treffen die meisten Entscheidungen in Bezug auf den Anbau, den Verkauf und das Einkommen durch ALVs und sind die zentralen Hüterinnen des ALV-Saatgutsystems. Das Verständnis der genderspezifischen Dynamik innerhalb der Haushalte und des genderspezifischen informellen Saatgutsystems von ALVs ist für die Unterstützung des ALV-Anbaus, der gemeinschaftlichen Saatgutbankinitiativen und der Projekte zur Erhaltung des ALV-Saatguts in den Betrieben unerlässlich.

1. Introduction

African Leafy Vegetables (ALVs) have an enormous potential for food sovereignty and nutritional security. The cultivation and consumption of ALVs in Kenya has been increasing over the past 30 years, in part due to the growing awareness of their high nutritional value (Gotor and Irungu 2010, Mwaura et al. 2013, Pincus et al. 2018), due to the multiple advantages of ALV cultivation for smallholder farmers compared to other crops (Abukutsa-Onyango 2007, Chweya and Eyzaguirre 1999, Mwaura et al. 2013), and due to an increase in urban consumer demand (Chelang'a et al. 2013, Mwaura et al. 2013). However, the main constraint of ALV cultivation in Kenya is the lack of available and accessible quality seeds (Chadha et al. 2007, Pincus et al. 2018, Srinivasulu Rajendran et al. 2016), a challenge faced by smallholder farmers worldwide and a major contributor to rural food insecurity. Seed insecurity remains a yearly challenge, as the demand for ALVs seeds is in many cases far higher than what the informal and formal seed markets can deliver (Pincus et al. 2018). Informal seed systems are the main source of seeds for smallholder farmers in Western Africa (McGuire und Sperling 2016, Pincus et al. 2018) and are vital for in-situ conservation, maintaining and increasing agrobiodiversity and ensuring future crop improvement around the world (Badstue et al. 2006, Coomes et al. 2015, Stromberg et al. 2010).

Women are responsible for the cultivation of many crops worldwide, such as ALVs in Kenya. However, women's perspectives, knowledge and experiences have historically been excluded from agricultural research and development (Chambers and Momsen 2007, Ferguson 1994). Not only are ALVs in western Kenya predominantly cultivated, handled and marketed by women (Nekesa and Meso 2018, Pincus et al. 2018), but women are as well responsible for seed production, selection, conservation, and storage (Almekinders and Louwaars 2002, Gill et al. 2013, Nkengla-Asi et al. 2020). They are the holders of agroecological knowledge on seeds and varieties (Delêtre et al. 2011). Utilizing a gendered perspective on agriculture and in particular on ALV cultivation and seed systems highlights the gendered social organization of labor and power. Understanding women's participation and decision making ability, and access to and control over productive assets, is essential for gender equality, with intrahousehold power dynamics influencing who finally benefits from increases in household income through ALV cultivation (Doss 2013, Nkengla-Asi et al. 2020, Quisumbing 2003b). Women-controlled resources can not only increase their bargaining power in the household, but can also improve the situation of women and children's health, nutrition, and education (Quisumbing 2003a).

This thesis is embedded in the project from Bioversity International in Kenya: *'Improving access to and benefits from a wealth of diverse seeds to support on-farm biodiversity for healthy people in resilient landscapes'.* It has the applied purpose of supporting ALV cultivation, ALV community seed bank initiatives and on-farm ALV seed conservation projects in Kenya. The aims of this thesis are to (1) identify which ALVs are cultivated and which factors influence cultivation, to (2) identify the sources of ALV seeds and which factors influence the informal seed system, and finally (3) to describe and analyze the extent in which women participate in and make decisions about the cultivation of ALVs. To fulfill these aims, data was taken from a baseline survey of 446 households done in 2018 in Vihiga County, located in the Lake Victoria Basin in Western Kenya.

2. State of the Art

2.1. African Leafy Vegetables

2.1.1. Definition

> "To define what is and what is not a vegetable was found to be far from easy, so that rather than attempting to redefine the meaning of the word, reliance was made on what local people considered to be vegetables." (Schippers 2000)

Scientific publications use different terms, sometimes interchangeably, to describe the over 1000 species of vegetables that have been cultivated or gathered in many parts of Africa for generations (Pincus et al. 2018). These species are either indigenous or have become naturalized in the culture and are very diverse, reflecting not only the diversity of plants but of the African cultures as well. These vegetables typically fall under the category neglected or underutilized species, as they are seldom integrated in national and international development plans, are not sold on the global market, and are rarely researched (Chelang'a et al. 2013, Chweya and Eyzaguirre 1999). However, these vegetables hold an enormous potential for food and nutrition security, sustainable livelihoods and are an integral part of localized culture and agrobiodiversity (Abukutsa-Onyango 2007, Towns and Shackleton 2018). The terms used include African leafy vegetables, traditional leafy vegetables, indigenous vegetables, African indigenous vegetables, indigenous leafy vegetables, leafy vegetables and finally traditional vegetables (Towns and Shackleton 2018).

I will use the term African leafy vegetables, or ALV, to describe vegetable species cultivated in Africa for consumption of their leaves. ALVs are indigenous or naturalized, in contrast to the main "exotic" vegetables found on the global market.

2.1.2. ALVs in Kenya

The cultivation of ALVs has been increasing over the past 30 years, with most farmers in Kenya growing one or more species of ALVs (Gotor and Irungu 2010, Mwaura et al. 2013, Pincus et al. 2018). This increase is primarily consumer driven, with the demand for ALVs growing year by year (Mwaura et al. 2013). ALVs are now sold not only in rural areas, but as well in peri-urban and urban areas, with urban consumers willing to pay premium prices for ALVs (Chelang'a et al. 2013). ALV consumption in Kenya has also been increasing through a growing awareness of their nutritional value. ALVs are high in micronutrients, such as vitamin A, B, and C, as well as minerals such as calcium, iron, zinc, and potassium (Gotor and Irungu 2010, Pincus et al. 2018). A small portion of ALVs can contain more than 100% of the daily recommended amount of vitamins and minerals, as well as be an important source of protein for children (Abukutsa-Onyango 2007).

2.1.2.1. Cultivation

There are four different ways in which ALVs can be cultivated or collected (Chweya and Eyzaguirre 1999, Mbugua et al. 2011). First, they can be gathered from wild plants or bushes in the fields. Second, they can be semi-cultivated as "weeds", where the plants are either weeded out or left to grow alongside planted crops. Third, ALVs can be harvested from crops which are not primarily grown for their leaves, but rather for their seeds, tubers, or fruit. And fourth, ALVs can be explicitly cultivated solely for their leaves, with varieties selected specifically for their leaf characteristics. This last category of ALVs is the one I will focus on.

In Vihiga county, Kenya smallholder farmers own between 0.5 and 5 hectares of land, of which around 5% to 30% is used for the cultivation of ALVs (Mary Abukutsa-Onyango 2007). ALVs are grown either in the home or kitchen garden, or as an intercrop between cereals, legumes, root crops, and fruit trees. As with other agronomical activities, everything is done by hand, from land preparation to planting and

weeding. Seeds are either sown in rows or broadcasted on the plot, with no specific spacing (Chelang'a et al. 2013). Farmyard manure is the main source of fertilization. In general, ALVs are grown with few agricultural inputs (Pincus et al. 2018) and in Vihiga county, no farmers reported using chemical fertilizers for ALV cultivation (Mary Abukutsa-Onyango 2007). Seeding is done at the beginning of the two rainy seasons, i.e., in March and in September, with a continuous harvest starting around 4 weeks after sowing. Harvesting is done at a weekly basis, removing young shoots and leaves, and can continue for a period of three months. If seeds are desired, ALVs are matured for another two months until seed collection (Abukutsa-Onyango 2007).

The following factors significantly influence farmers decisions to cultivate ALVs in the Kiambu District near Nairobi: income, primary occupation of the farmer, distance to market, access to extension services, access to technical support and distance to piped water source (proxy as access to water) (Mwaura et al. 2013). Income is negatively related with ALV production, with an increase in household income resulting in a decrease in the probability that a household cultivates ALV. At the same time, those households which depend primarily on farming are more likely to cultivate ALVs. Importantly, the distance to the market also plays a part, with those households closer to the market significantly more likely to cultivate ALVs than those farther off. There is a negative relationship between ALV cultivation and distance to piped water supply, i.e. the nearer a household is to a piped water source, the more likely the household cultivates ALVs. Access to extension services as well as access to technical support both have a significant positive influence on ALV cultivation. The following factors were not shown to significantly influence farmer's decision to cultivate ALVs in Kenya: household size, age, gender, education, marital status, experience in farming, land size, and credit (Mwaura et al. 2013).

2.1.2.2. Opportunities and Challenges

There are multiple advantages for smallholder farmers when cultivating ALVs. ALVs not only have a short production cycle, with a harvest possible within a few weeks, but also can be continuously harvested over the course of many months. In addition, ALVs have low nutrient demands and can therefore be cultivated on poor soils (Chweya and Eyzaguirre 1999), with little fertilization (Abukutsa-Onyango 2007). ALVs also have a high tolerance for biotic and abiotic stresses (Abukutsa-Onyango 2007). All these factors make it an ideal crops for smallholder farmers who often have small plots and limited resources (Mwaura et al. 2013).

There are also many benefits of cultivating ALVs when compared to "exotic" vegetables, such as cabbage or spinach. ALVs have lower production costs due to lower fertilization requirements and less expensive seeds. Input costs can be lowered further if farmers produce their own seeds, as is possible with the open pollinating ALVs species but not for many "exotic" vegetables. Additionally, there is less of a pest and disease pressure for ALVs than crops such as kale and ALVs are more drought resistant (Chweya and Eyzaguirre 1999). The lower production cost is paired with an increase of harvests per year, as ALVs have a fast rate of maturity and can be continuously harvested (Chweya and Eyzaguirre 1999). Finally, there is a high consumer demand for ALVs, with not only relatively high prices but also a potential growth of the market (Muhanji et al. 2011).

There are various potential agronomic advantages for smallholder farmers when cultivating ALVs. Certain ALVs, such as cowpea or slender leaf, are nitrate-fixing plants, and can be used as an intercrop with maize, thereby improving soil fertility and nitrogen levels in the soil (Mbugua et al. 2011). In addition, intercropping can reduce soil evaporation, enabling maize to withstand dryer periods. During the rainy season, the cover crop can reduce the impact of rainwater on the soil and soil erosion. Finally, intercropping ALVs can suppress other non-edible weeds and some ALV species can reduce parasite pressures (Mbugua et al. 2011, Nekesa and Meso 2018).

With all the advantages mentioned, smallholder farmers still face many challenges with the production of ALVs. The main challenge is a limited access to seeds, as well as poor seed quality (Abukutsa-Onyango 2007). Other challenges include pest and disease pressure, drought and the lack of irrigation, low yields, and poor marketing channels, with low market prices, competition with “exotic” vegetables, and insufficient transport means to the market (Chweya and Eyzaguirre 1999, Mbugua et al. 2011). ALV markets and market chains are not really developed or established and face fundamental difficulties (Pincus et al. 2018). Leafy vegetables are highly perishable and face enormous challenges for proper storage (Chweya and Eyzaguirre 1999).

While there has been an increase in ALV cultivation, there has also been a decrease in ALV collection in the wild, which faces many challenges due to population increase and climate change (Gotor and Irungu 2010). This is partnered with a continuous loss of indigenous knowledge regarding African vegetables. The loss of indigenous knowledge is attributed to the introduction of new "exotic" vegetables, to governmental agriculture and health policies, changes in lifestyles, and cultural stigma branding ALVs as a "poor" person’s food (Dweba and Mearns 2011).

2.1.2.3. Description of most common ALV species in Western Kenya

There are over 200 species of ALVs cultivated in Kenya (Chelang’a et al. 2013), however I will focus on those ALVs which are explicitly cultivated solely for their leaves, with varieties selected specifically for their leaf characteristics. The following ALV species are the most cultivated species in Western Kenya: *Vigna unguiculata* (cowpea leaves), *Amaranthus spp*. (amaranth), *Crotalaria brevidens/C. ochroleuca.* (slender leaf), *Solanum villosum/S. scabrum* (African nightshade), *Cleome gynandra* (spider plant), and *Corchorus olitorius* (jute mallow). Additionally, *Cucurbita spp*. (pumpkin leaves), *Brassica carinata* (Ethiopian Kale), *Basella alba* (Vine/Malaba spinach) and *Manihot esculenta* (cassava leaves) are cultivated, although to a lesser extent (Abukutsa-Onyango 2005, Abukutsa-Onyango 2007, Chweya and Eyzaguirre 1999, Croft et al. 2018, Onyango et al. 2013, Weinberger et al. 2011). In the appendix, Table 4 provides an overview of the binomial nomenclature, the common English name I will be using, as well as the Luhya, Luo and Kiswahili name used by smallholder famers in Vihiga County, Kenya.

Cowpea leaves

Cowpeas (*Vigna unguiculata)* are indigenous to Africa and have been cultivated over centuries, leading to a plethora of varieties (Chweya and Eyzaguirre 1999). While there is extensive literature on cowpeas used as a pulse crop, the varieties grown primarily for their leaves have been sidelined, even though they are an important source of leafy vegetables in arid and semi-arid areas. Varieties grown for cowpea leaves are drought resistant, with deep roots able to access soil moisture in deeper levels (Schippers 2000).

Amaranth

The main amaranth species grown in Africa are *A. gracezians, A. thunbergii, A. blitum, A. spinosus, A. dubius, and A.cruentus.* The most common amaranth species in eastern Africa are *Amaranthus blitum* and *Amarnthus cruentus*. A. blitum is thought to originally originate from the Mediterranean region. The most popular variety is the green-leafed variety, which goes by the Luo name of *dodoo. A. cruentus* has inflorescent large leaves which are twice as long as they are wide, as well as pointed leaf tips. It most likely originated from Central America and is a common weed in cultivated fields. In Kiswahili, this species is called *mchicha* (Schippers 2000).

A. blitum and *A. cruentas* can be broad sown in a plant bed and harvested as a whole plant (and subsequently sold at the market) or it can be sown or transplanted in the kitchen garden, where side shoots and leaves are harvested continuously. Amaranth is a C4 plant, where the photosynthesis cycle works more efficiently when there is sufficient light, water, minerals, and a high temperature compared

to C3 plants. *Amaranthus* can be harvested four to five weeks after sowing. The seeds are either collected and purposefully sown or are left to fall naturally from the plant to the soil and germinate the following year. Amaranth do appreciate fertilized soils, with high levels of nitrogen delaying flowering and thereby increasing the yield. Ideally, organic matter or well-fermented manure can be used as fertilization. Drought stress lead to an early flowering by *Amaranthus*. Therefore, irrigation would be ideal, although this is rarely done outside (peri)-urban areas (Schippers 2000).

Amaranth species are anemophily plants, i.e. the pollen is spread by the wind. *A. blitum* and *A. cruentus*, are both monoecious, i.e. the staminate and pistillate are both on one plant. Due to the large amount of pollen produced and its anemophily, there is a high level of self-pollination, but it is also very easy for varieties to cross with one another. That is why different varieties need to be isolated and separated by at least 200 meters if cultivated for its seed (Schippers 2000).

Slender leaf

The genus *Crotalaria* is a leguminous plant, and two *Crotalaria* species are used in leafy vegetables in Eastern Africa, *Crotolaria ochroleuca* and *crotolaria brevidens*. Both species grow wild and are cultivated as a leafy vegetable. Slender leaf is grown either as a monocrop or intercropped with finger millet or other vegetables which benefit from the nitrogen fixating and nematode suppressing attributes of *Crotalaria*. This is also the reason why it is an ideal plant in a crop rotation system. While slender leaf is a nitrogen fixating plant, it does still grow stronger with fertilization. Slender leaf has few antagonistic pests or diseases and has a long taproot and long lateral roots, enabling it to reach soil moisture deeper in the soil. Farmers can either uproot the whole plant or harvest continuously after about 6 weeks. The side shoots can be harvested every two weeks and up to 15 times. The leaves are used fresh or dried and in soups (Schippers 2000).

The seeds of slender leaf are broadcasted in the plot and germinate easily after a few days. Slender leaf will start seeding after the farmers stop harvesting, which is generally at the beginning of the dry season. Slender leaf is mainly self-pollinating, enabling farmers to collect relatively pure seeds. These seeds are comparably expensive and can generate an income if sold at the local market (Schippers 2000).

Nightshade

African nightshade species belong to the *Solanum nigrum* complex. The most cultivated species in Eastern Africa are the purple-berried *Solanum scabrum* and the orange-berried *Solanum villosum*. Both species are indigenous to Africa and *S. villosum* has spread to southern Europe and the Middle East. African nightshade species are difficult to identify.

African nightshade is either sown directly or seedlings are transplanted. African nightshade requires larger amounts of nitrogen and other nutrients than other ALVs and has a high pest intolerance. African nightshade is first harvested after around 5 weeks, when the stem is cut, allowing for new growth of the side shoots. For *S. scabrum*, the harvest continues every one to two weeks and up to 4 times per plant. If the plant is sufficiently fertilized and irrigated, it can be harvested up to 10 times. *S. villosum* can be harvested weekly, with up to 10 harvests per plant, or can be uprooted as a whole plant. African nightshade can be eaten fresh, dried, or made into a "cake" through boiling with milk, compressing and fermenting. This is used as a substitute for meat in western Kenya (Schippers 2000).

African nightshades are predominately self-pollinating, with varieties easily stabilized and uniformed. However, there are bees and flies which can affect pollination. Therefore, plants cultivated for seed production should be planted in blocks, with the outer plants and their berries discarded. Collecting and preparing seeds from the berries of African nightshades is labor and time intensive. While *S. villosum* seeds can be bought from the Kenya Seed Company, seed availability remains a major constraint for African nightshade production (Schippers 2000).

Spider plant

Cleome gynandra is a member of the *Capparaceae* family, indigenous to Africa and grown in many predominantly low-rainfall regions in central, eastern, and southern Africa (Onyango et al. 2013). Spider plant is a C4 plant, with an efficient photosynthetic cycle. This efficient vegetative growth declines though with flowering, which is why flowers are typically removed. There is a wide diversity of spider plant varieties, with purple or green stems, short or long pods, small or large leaves etc. Spider plants can be bitter and some varieties are used for medicinal purposes (Schippers 2000). Spider plant is important for women, as its nutritious properties are known and eaten especially by pregnant and lactating women (Chweya and Eyzaguirre 1999).

Spider plant is often cultivated as an afterthought, with little attention given other than weeding. The plants can be left to reseed themselves, although farmers in drier areas do collect seeds and irrigate the crop. As a C4 plant, spider plant grows best in direct sunlight. Fertilization through farmyard manure and organic matter delays flowering, leading to higher yields of leaves. The seeds are sowed directly, as spider plant has a taproot, hindering transplanting. The seeds however do not typically germinate uniformly. Spider plant has a fast rate of maturity and can be continuously harvested after a few weeks or it can be uprooted as a whole plant, although this is seldom done (Schippers 2000).

Spider plant is open-pollinated and are monoecious, with flowers that are either protandry (facilitating cross-pollination through temporal means) or self-pollinating (Chweya and Eyzaguirre 1999). Breeding therefore is done in isolation, where late flowering and large leaves are selected, although there has not been a lot of research and breeding done in the past (Schippers 2000).

Jute Mallow

The genus *Corchorus* is most known for its species that produce fiber but there are several species which are cultivated and/or gathered as a vegetable, the most common one being *Chorchorus olitorius*. *C. olitorius* is considered to be indigenous to Africa, although there are many related species in Asia (Schippers 2000).

Jute mallow is commonly broadcasted, although some farmers sow directly or transplant seedlings, as the seeds have a high dormancy rate, hindering uniform germination. Jute mallow requires high soil moisture, which is why over 80% of production is during the rainy season. Harvesting is done either continuously up to four times or through uprooting the whole plant. This depends on the variety of jute mallow, with some selected for late maturing. Harvest can already occur after 4 weeks, and jute mallow can be dried and preserved in a powder form. However, the market value of jute mallow is low compared to other TLVs (Schippers 2000).

Farmers producing their own jute mallow seed select for rapid early growth, a late flowering, and large leaves. While *C. olitorius* is self-pollinating, up to 10% of seeds can be cross-pollinated. To produce jute mallow seeds, the dry stems and branches are beat with sticks to release the seeds from the capsule and then winnowed. If the capsules are harvested too late, the seeds are more likely to be dormant longer (Schippers 2000).

2.2. African Leafy Vegetable Seed System

2.2.1. Seed security, seed systems, and seed sovereignty

Obtaining quality seeds that meet the needs of famers is one of the most essential parts of crop production. Nonetheless, farmers in the Global South continue to face challenges accessing preferred quality seeds. Not only are there challenges regarding the material and physical access to seeds, which depend on the availability of seeds, but as well the reliability and availability of information about the quality of seeds (Schöley and Padmanabhan 2017, Stromberg et al. 2010). These challenges are

commonly addressed through three closely related concepts: seed security, seed sovereignty and seed systems.

The concept of seed security originates from emergency seed aid literature (Mulesa et al. 2021) and builds on four parameters, originally derived from food security: availability, access, utilization, and resilience (McGuire and Sperling 2011). The availability of seeds refers not only to a spatial proximity, but also a temporal availability, i.e. when farmers need seeds at a specific time for sowing. Access to seeds includes the capability of farmers to produce their own seeds, the resources required to obtain seeds and the relevant information needed. Seed utilization refers to whether seeds can meet the farmer's needs regarding quality and quality. And finally, resilience refers to the knowledge, skills, and planting materials which farmers need to maintain adequate seed quality and quantity (McGuire and Sperling 2011).

The concept of seed sovereignty builds on seed security and refers to the ability of farmers to control seed types, production, and distribution (Bezner Kerr 2013). Seed security does not automatically entail if farmers themselves have control or determination over the type of seeds they use or are included in breeding programs for new varieties. Farmer's control over seeds has been chipped away through the commercialization of breeding, the development of hybridization and genetic modification, and the subsequent development of national and international restrictive intellectual property rights (Kloppenburg 2010). Seed sovereignty addresses these issues by including the democratic principle of control over ones resources, bringing farmers to the forefront of seed policies, breeding programs, and conservation of agrobiodiversity (Bezner Kerr 2013).

Seed system research addresses the issue of seeds from a systems perspective, focusing not only on the actors and institutions, but as well the structures that influence the development, distribution and use of seeds (Mulesa et al. 2021). The term seed system describes the network of seed channels which supplies farmers with seeds as well cuttings, pseudostems and tubers from (un-)domesticated plants. Literature on seed systems normally distinguish between two seed systems, the formal and informal system (McGuire 2008). The aim of seed system research is to improve seed security and seed sovereignty, as well as support crop and species diversity (Badstue et al. 2006).

2.2.2. Formal seed system

The formal seed system is characterized by (trans-)national regulations, certified seeds, and property rights of commercial breeders. The channels in the formal seed system, through which smallholder farmers access seeds, take place in research stations, (non-)governmental institutions and commercial seed suppliers, such as agro-vet shops. The formal seed system is a global system, impacted by global markets and global agro-businesses, especially trans-national seed corporations (Louwaars and Boef 2012). The historical development of the formal seed system in the Global North was partly advanced by new breakthroughs in genetics, such as heterosis, and the following commercialization of breeding. This development was on par with the general increase of inputs in farming, including fertilizers, chemical crop protections, and machines. This led to a more specialized and larger farm structure, with the formal seed sector supplying reliable and uniform seeds, protected by a range of new seed laws (Almekinders and Louwaars 2002).

In the Global South, the development of the formal seed system took a different path, gaining in importance during the "Green Revolution" with the introduction of hybrid seeds of the major food crops, such as rice and wheat. The breeding programs were often initiated by public and private foundations, such as the Consultative Group of International Agricultural Research (CGIAR). These foundations focused on reaching as many farmers as possible in the Global South with high yielding varieties of the major food crops and were biased towards high potential areas. It is debated whether the "Green Revolution" improved the living conditions of farmers in the Global south, since the seed varieties were most successful in favorable agro-ecological conditions (Almekinders and Louwaars 2002).

The formal seed system has several limitations when it comes to supplying seeds for smallholder farmers in the Global South. Even though national and transnational policies have focused predominately on the formal seed system and have had success in increasing the quality and accessibility of seeds, this has worked mainly for the few main cash crops that are sold on the global market (Louwaars and Boef 2012). Breeding and improving traditional vegetables for example is often not feasible and economic for seed companies, as the demand and growth potential is limited (Almekinders and Louwaars 2002). Formal markets are not able to react to the small quantities of seeds demanded by smallholder farmers, the dispersed and hard-to reach location of smallholder farmers and the changing demands made (McGuire and Sperling 2016). In addition, while formal seed markets are able to supply higher-yielding and higher quality seeds, they may not be able to supply seeds that have the same resilience to local biotic and abiotic stresses as farm-saved seeds. Finally, while NGOs have been increasingly investing in seed aid, these programs may be lowering the price of seeds on the local market, thereby limiting the development of local farmer-run seed enterprises (Croft et al. 2018).

2.2.3. Informal seed system

The informal seed system is characterized by social relations, cultural norms, and localized structures (Ricciardi 2015). Smallholder farmers access seeds through local markets, farmer-to-farmer exchanges, social networks including family relations, and by collecting and producing their own seeds (Louwaars and Boef 2012). Farmers use different types of transactions (cash based, trade, gift, inheritance etc.) to exchange predominantly local varieties, non-certified improved varieties, and open-pollinated varieties (Schöley und Padmanabhan 2017). The informal seed systems are constituted by kinship relations, gender dynamics, market dynamics, development policies and regimes, and climatic factors (Ricciardi 2015).

Although more research, development, and investment are focused on the formal seed system, the informal seed system remains a key pillar of farmer livelihoods and small-scale agriculture. Smallholder farmers in the Global South source over 90% of their seeds from the informal seed system (McGuire und Sperling 2016). Smallholder farmers save and exchange seeds to lower input costs, for experimentation of new varieties, to aqcuire planting material, to mitigate seed loss, etc. Farmer seed systems are sometimes the only source of local varities and underutilzed crops, which are not bred on the formal market (Schöley und Padmanabhan 2017).

Farmer seed systems are not closed systems that just recycle older varieties and exchange them sporadically among farmers. Rather, farmers breed new varieties from genetic material found in their community, in the wild and in the formal seed system (Coomes et al. 2015). Through the exchange of seed varieties among farmers in relatively isolated networks, these seeds can adapt to specific production environments and lead to the development of local genotypes, thereby maintaining agrobiodiversity (Abay et al. 2011). Agrobiodiversity is a key part of food sovereignty and food security, especially in times of climate change, land use intensification, urbanization and structural change in the rural population (Pautasso et al. 2013). Farmer seed systems are vital for in-situ conservation, including genetic, morphological and varietal diversity of plant populations, increasing seed diversity and building the basis for crop improvement around the world. (Badstue et al. 2006, Coomes et al. 2015, Stromberg et al. 2010). Importantly, farmer seed systems are often the only source of seed for traditional crops and varieties, as well as neglected and under-utilized species (Gill et al. 2013).

While informal seed systems have been the basis of seed supply for smallholder farmers (and continues to be the only source of seed for local and underutilized crops and varieties), it suffers from many limitations and marginalization. Seeds are not always available in the informal seed systems, with natural and social disturbances leading to seed shortages (Louwaars and Boef 2012). The quality of seeds may be compromised, stemming from disease pressure, poor germination capacity, degeneration etc. In general, there is little investment in the seed system, with minimal technical

support for seed growers and breeders. The dominant agricultural development regime promotes large-scale policies and initiatives by agribusinesses, supporting the interests of (trans-)national seed companies. Quality seed is thought to only stem from commercial or governmental seed breeders, with the private seed sector the only avenue for the dissemination of seeds. Informal seed systems are considered inefficient, unreliable, with low quality seeds. This is why many countries have passed regulations weakening the informal seed system, as it is considered a hindrance for the modernization of agriculture (Coomes et al. 2015). Kenya's National Seed Policy recognizes the existence of the informal seed system, but excludes it from any development plans and bans farmer seed exchanges and informal purchases (Mucioki et al. 2018).

Research on the informal seed system focuses on social system and networks of seed exchanges (Abay et al. 2011, Badstue et al. 2006, Badstue et al. 2007, Gill et al. 2013, Kiptot et al. 2006, Ricciardi 2015), on in-situ conservation, agrobiodiversity and the diffusion of new seeds (Leclerc and Coppens d'Eeckenbrugge 2012, Pautasso et al. 2013, Stromberg et al. 2010, Tadesse et al. 2017) and seed system development (Almekinders and Louwaars 2002, Coomes et al. 2015, Louwaars and Boef 2012, McGuire and Sperling 2013, Mucioki et al. 2018, Mulesa et al. 2021, Sperling and McGuire 2010). This is done through ethnographic studies, social network analysis, surveys, and genetic analysis. The aim is oftentimes conserving species diversity and strengthening human relationships in informal seed systems (Ricciardi 2015). Research on informal seed systems, while growing, is still underdeveloped and underfunded. Little is known about even seed networks of major crops such as maize, and even less of traditional and underutilized crops (Gill et al. 2013). Smallholder farmers in the Global South rarely keep records of their seed transactions and it is therefore difficult to make precise seed flows. When estimating seed flows, researchers are dependent on the recalled accounts given, and farmers will more likely remember their seed acquisitions in contrast to their seed distribution (Badstue et al. 2006).

2.2.3.1. Seed Sources in the Informal Seed system

In the last 20 years, the number of seed sources utilized by smallholder farmers in the Global South has increased. In the past, farmers would obtain their seeds from two main sources: the farmers own seed stocks and neighboring farmers. The transaction type was primarily barter and the species primarily traditional varieties. This has changed, with smallholder farmers utilizing formal as well as informal seed sources and accessing traditional as well as "improved" varieties with a range of different transaction types (Schöley and Padmanabhan 2017).

While farmers do not always source their seeds each year from the same person per se, they are likely to use the same general source in the informal seed system, either the local market, own stock, friends/neighbors/relatives and/or community-based seed groups (Violon et al. 2016). A large study by McGuire and Spering (2016) showed that the local market is by far the main source for seeds, accounting for 50.9% of all seeds obtained. The second most import source was the farmer's own stock, accounting for 1/3 of the seeds sown and varying between 28% and 45% of seeds, depending on the site in Africa. Seeds from friends/neighbors/relatives accounted for almost 10% of the total seed, while seeds from community-based seed groups were less than 1%. The sources of seeds were highly determined by the crop cluster (cereals, legumes, vegetatively-propagated crops, and maize) (McGuire and Sperling 2016).

Local Market

The local market brings together many different types of seed traders and vendors, each working on different levels in the informal and formal seed system. At the top are big traders, who sell their seeds to distant areas and sell down to the medium-level traders. The medium-level traders may either get their seeds directly from farmers, seed collectors or grain millers, while supplying seeds directly to farmers. Collectors link farmers and bigger merchants, buying and selling seeds to farmers and

traders. And finally, farmers themselves may sell at local markets, in addition to selling their seeds to collectors or medium-level traders (Sperling and McGuire 2010). In Tanzania, farmer-produced seeds are a stream of income for more than half of smallholder farmers, especially for local seed entrepreneurs (Pincus et al. 2018).

Farmers source their seeds from local markets for multiple reasons. First, farmers use local markets to access new varieties, often buying only small amounts of seeds for experimentation. Second, farmers turn to markets in times of crisis, where their own seed stocks and those in their community are depleted. This depletion may stem from poor yields, where farmers will prioritize consumption or sale over storing seeds, or it may stem from seed loss due to poor storage, unforeseen crisis, insufficient germination, or loss of seedlings. Local markets are in many cases more flexible than seed aid, as farmers are more able to choose crops and varieties according to their needs. Third, there is a general trend away from seed exchanges between farmers and in the community and toward local markets. Social networks key for farmer exchanges appears to be eroding, due to commercialization and labor migration away from farming. Fourth, farmers are able to outsource seed production and storage through the local market. In cases where seed sellers are trustworthy, farmers access quality seeds and meet stricter standards in the national and global markets (Sperling and McGuire 2010).

When selecting seeds in the local market, farmers weigh various factors, looking at variety quality and seed quality. In addition, farmers weigh the trustworthiness of different seed traders. Because local markets and the seeds sold there are not subjected to formal regulation and certification, farmers must rely on social regulation and certification to assess who sells quality seeds. Social certification is based on the experiences of the farmer and the sellers reputation (Sperling and McGuire 2010). Farmers perceive a considerable risk from sourcing seeds from an unrelated source, as the seed could have diseases or have other unfavorable characteristics (Badstue et al. 2007).

The local and informal markets where seeds are sold have received little attention by researchers, policy makers and (non-)governmental organizations. This is because on the one hand, the production of on-farm seeds is over-emphasized in importance for seed security, with the use of off-farm seed channels interpreted as a sign of vulnerability. On the other hand, seeds from the local market are not considered seeds at all, as they are not labeled as such and could be used in the case for cereals, as food (Sperling and McGuire 2010).

On-farm seed production

The second most important source of seeds for smallholder famers is the farmers own stock or on-farm seed production. Farmers have multiple reason for producing seeds on their farm: community respect, goods exchanges, home consumption, income from seeds, maintaining variety, seed exchanges, reducing input costs and a sense of security (Pincus et al. 2018). With on-farm seed production, farmers are not only able to control their own access to seeds, but they also have their own knowledge and experience regarding the traits of the seeds (Stromberg et al. 2010). In addition, some farmers perceive their own seeds with affection, with their seeds having a symbolic value. Saving seed contributes in some areas to the identity of a "good farmer" (Badstue et al. 2007).

There are multiple reasons why farmers do not save seeds for replanting the next year but rather obtain seeds from external sources. One reason may be seed loss, hindering an adequate amount of seeds needed for cultivation. This can stem from crop failures, storage losses, a low production resulting in the consumption of all the crops or selling all the seeds. Another reason for obtaining seed from external sources is seed renewal, which is necessary to combat seed degeneration, inbred depression, and seed diseases. Finally, farmers also experiment with new species and varieties (Stromberg et al. 2010).

F**armer-to-Farmer seed exchanges**

Farmer-to-farmer seed exchanges refer to seed exchanges between relatives, neighbors, friends, and acquaintances (these categories not mutually exclusive). These exchanges are embedded in a social system, determined by the relationship between farmers. Obtaining seeds from close social relations has many advantages. In terms of cost, these can be lower due to social ties and responsibilities, and the transaction can be done ad hoc and part of an ordinary social interaction. In terms of trust, farmers will not only have confidence that they are obtaining seeds that match their preferred characteristics and quality, but also have first-hand experience on how they grow. In addition, the varieties have probably been cultivated and bred in the same community under similar conditions (Badstue et al. 2006).

However, while farmers are most likely to source their seeds from in the village, they may utilize their social network to source seeds outside the village if seeds are scarce. For example, the agroecological condition of the farmland may be too poor for seed production, where farmers are unable to replace their seed every year. In this case, farmers may turn to other communities for seeds from relatives or non-relatives (Abay et al. 2011). Additionally, farmers do not solely source seeds for continuing their cultivation, but as well for experimentation. They experiment with new varieties and with new species. In Oaxaca, Mexico, the main reason for exchanging maize seeds is experimentation, with over 30% of maize seeds exchanged for this purpose (Badstue et al. 2007).

When obtaining new seeds, trust is an important factor in the social seed networks of small holder farmers. Thereby, farmers obtain their seeds from trustful sources, predominately from relatives (Delêtre et al. 2011, Kiptot et al. 2006, Tadesse et al. 2017) or custodian farmers, who actively select, maintain, and disseminate agricultural biodiversity through seeds (Sthapit 2013). Sharing information and experiences between farmers who are family members, friends or neighbors was reported to be the most frequent way to obtain information about seeds. Additionally, sharing information enables farmers to broaden their seed sources, so that they are not dependent on one single supplier (Badstue et al. 2006).

While farmer-to-farmer exchanges distribute seeds through social networks, this distribution is governed by social and cultural norms (Coomes et al. 2015). This means that structural discrimination influences who is able to access which seeds. Those who are most marginalized in society are most marginalized in their access to seeds, this including women (especially widows), orphans, tenant farmers, lower-caste farmers, Aids-affected households, migrant farmers etc. (Bezner Kerr 2013). At the same time, social and cultural norms influences the flow of seeds, determining the connectivity of individuals in the community and therefor the exchanges of seeds and information (Delêtre et al. 2011). Kinship systems, migration and ethnolinguistic boundaries can either promote or hinder the diffusion of seeds (Coomes et al. 2015).

For many smallholder farmers in the Global South, seeds are not just an agricultural input, but rather a part of a farmer's identity as well as a source of wealth and pride. How seeds are seen by farmers defines with whom they are shared. In addition, if seeds are perceived as a source of wealth, seed sharing can be seen as charity and entail debt or obligation. This is why some farmers prefer to source their seeds from the local market instead of from their neighbors, which can be framed as begging or require money, seeds or service in exchange (Badstue et al. 2007, Coomes et al. 2015).

While there are many advantages for obtaining seeds from close social relations, they only apply if a farmer has multiple sources of seed and can chose between the sources. While a farmer theoretically may trust their close social relations, this does automatically mean that the seed they obtain will have the preferred characteristics and quality they need. For crops where seed sources are scarce and hard to come by, farmers might obtain seeds from a neighbor or close relative with the knowledge that the quality is not good (Badstue et al. 2006).

Community seed banks

The origin of plant breeding and the development of domesticated cultivators stem from farmers saving and exchanging seeds in the community. The concept of community seed banks formed around three decades ago and refers to local, participatory institutions that select, conserve, multiplicate, exchange and improve seeds for local farmers. This happens outside the formal seed system, although most seed banks are heavily supported by NGOs (Vernooy et al. 2014).

Community seed banks have three core functions. First, they enable communities to manage their agricultural biodiversity, contributing to in situ conservation (conservation of plant genetic resources on the farm and in the wild). Second, community seed banks can improve the access and availability of local crop diversity and third, can ensure seed and food security (Vernooy et al. 2014). Not only are farmers able to access a diversity of crops and varieties from community seed banks, but they are also able to exchange information between themselves, as well as receive knowledge, such as improved storage techniques, from the community seed bank itself (Porcuna-Ferrer et al. 2020).

Community seed banks and participatory plant breeding initiatives can increase the access and availability of seeds of local varieties and improved cultivars for smallholder farmers (Sthapit 2013). Through its decentralized nature, community seed banks can also operate as a central node in the seed system, linking farmers with the formal seed system, national and international gene banks, and breeding programs These linkages were shown to increase the social-ecological resilience of local communities in Guatemala (Porcuna-Ferrer et al. 2020).

One of the key drivers for implementing community seed banks is the access to local varieties. The number of farmers cultivating local varieties and collecting seeds is in a continuous decline, as well as the land used for cultivation. With farmers often only connected with a few farmers, access to local varieties becomes strained. In addition, new varieties, such as those coming from participatory plant breeding programs, often have minimal adoption rates because of low farmer-to-farmer exchange (Ricciardi 2015). Community seed banks sometimes become the only source of viable, traditional varieties (Sthapit 2013).

Community seed banks may be able to provide marginalized households or groups with seeds since the seeds sourced from the seed bank are usually not paid with money, but rather with seeds harvested in the next season. In addition, in times of crisis, a community seed bank may be a back-up source if seeds are lacking on-farm and in the community (Vernooy et al. 2014). However, community seed banks are influenced by social and cultural norms and are not automatically egalitarian institutions. Women, resource-poor farmers and minorities are less likely to be involved in community seed banks, reflecting the structural inequalities of the community (Porcuna-Ferrer et al. 2020).

Community seed bank initiatives face many challenges. Not only do community members participating in the seed bank often lack time and resources to fully implement the goals of the seed back, but members also have limited technical knowledge and skill for ensuring seed quality (Vernooy et al. 2014). Additionally, community seed banks have few linkages to other community seed banks and are rarely able to exchange seeds and information(Vernooy et al. 2014). Finally, community seed banks rely on the idea of collective action in genetic resource conservation (Badstue et al. 2006). If no collective action is found in a community, then it is questionable if community seed banks are a useful and successful tool. Interventions directed more towards individual farmers or toward already established local institutions that have a broader purpose may be a more effective strategy for ensuring seed diversity (Badstue et al. 2006).

2.2.3.2. Types of exchanges

When looking at seed systems, it is not only important to understand which channels are used by smallholder farmers, but also to identify how they access seeds in each channel. Seed transactions

can be classified into seven categories: purchase, inheritance (either after death of parents or when children become independent), exchange (between varieties and species), gift, aid from developmental or emergency seed programs, barter (exchanged for good or services), borrowed (seeds of future harvest are to be returned), or other (sharecropping, gleaning, ect.) (Badstue et al. 2006, McGuire and Sperling 2016). Understanding seed transactions can be informative when looking at seed vulnerability and to what extent the community supports its members through seed gifts (Tadesse et al. 2017), to what extent farmers use cash to pay for seeds, and what farmers might be willing to spend (McGuire and Sperling 2016).

In Kenya, smallholder farmers sourced their seeds using the following transaction types: 53.9% of seeds were bought, 36.1% came from their own stock, 4% came from direct seed distribution, 3.3. % were gifted, 2% were loaned, and 0.7% were exchanged, vouched or obtained through food aid (McGuire and Sperling 2016). However, these exchange types do not correlate with one specific channel. When obtaining seeds from a neighbor, exchanges could be with seeds, with labor, or bought etc. (Tadesse et al. 2017). Additionally, transaction types are not set in stone but can rather change with each exchange (McGuire and Sperling 2016).

The relationship between the supplier and recipient influences the type of transaction, i.e. if it is a gift, bartered or purchased. Among those who are related to one another, inheritances and gifts are the most common transaction. Purchasing seed was one of the most common forms of transaction among all social relationships but especially among acquaintances and strangers. Badstue et al. (2006) conclude that with more social distance between supplier and recipient, the frequency of purchasing increases while gift and inheritance decreases. In the end though, no transaction type is restricted to one social relationship.

2.2.3.3. Variables determining seed source

Multiple studies have looked at the variables affecting why farmers choose different seed sources (Cavataasi et al. 2006, Croft et al. 2018, McGuire and Sperling 2016, Stromberg et al. 2010, Tadesse et al. 2017, Violon et al. 2016). These variables fall into the broad categories of household/farmer characteristics (crop, gender, age, education), resource availability (on-farm and off-farm assets) and market access (market participation, extension access) (Croft et al. 2018).

When looking at household/farmer characteristics, the sources of seeds are highly determined by the crop cluster (cereals, legumes, vegetatively-propagated crops, and maize) (McGuire and Sperling 2016). Age can significantly influence selection, with younger farmers more likely to source seeds from the local market than older farmers (Croft et al. 2018) and older farmers more likely to provide seeds than acquire seeds (Wencélius et al. 2016). Education however was not proven to influence seed source determination (Croft et al. 2018).

The economic situation of a household affects the ability to acquire seeds, especially in years that are climatically difficult for farmers (McGuire and Sperling 2016; Violon et al. 2016). Wealthier households that either have more land or off-farm income, are able to cope with uncertainty through their material and social resources (Croft et al. 2018), and are most likely to share their seeds or tubers with medium wealthy or poor farmers (Tadessee et al. 2017). Additionally, the larger the area of land cultivated by one household, the more likely they are to use their own stock for reseeding next year and the less likely they are to buy from the local market (McGuire and Sperling 2016). However, wealthier households are not as dependent on their own seed production, as they have more access to other sources (Gill et al. 2013). Vulnerable households, who cultivate on less land, have less material resources and rely more on their neighbors or the local market as seed sources (Violon et al. 2016). In difficult climatic years, farmers in Cameroon sometimes refrain from asking for seeds from their limited networks, as it is considered begging and therefore shameful (Violon et al. 2016). On the other

hand, farmers in Ethiopia share their seed with others out of a feeling of social responsibility for their community (Tadesse et al. 2017).

The ability of farmers to access markets either for sourcing seeds or selling crops can influence which seed source is utilized by the farmer (Cavataasi et al. 2006, Croft et al. 2018, Stromberg et al. 2010). In Peru, the proximity of markets can increase the income of farmers, thereby leading farmers to increase their input costs and buy seeds, instead of using land and labor-intensive seeds produced on their farm (Stromberg et al. 2010). Farmers in scattered Peruvian villages with inadequate infrastructure are more likely to rely on localized seed stocks, as they are more isolated from other villages and external seed sources (Stromberg et al. 2010). In Ethiopia, village isolation stimulates sorghum seed saving, but also hindered seed renewal (Cavataasi et al. 2006), and in Peru, linguistic differences are an isolating factor in seed flows (Stromberg et al. 2010).

2.2.4. Beyond the divide: informal vs. formal seed systems

Seed systems are typically divided into two dichotomous categories, the formal and informal system. There are however certain critiques to this categorization. First, the depiction of a formal and informal seed system reinforces misconceptions about the later. While the informal seed system does not have the same legislative regulation as the formal system, it is not informal per se in that it does have social rules and norms which govern it (McGuire and Sperling 2016). In addition, it is greatly influenced by the decisions made in the formal system and therefor is not purely a local system. Second, the informal and formal systems do not work independent of each other but rather are intertwined by the farmers, traders and the seeds themselves (Coomes et al. 2015).

However, other than through farmers, traders, and seeds, the formal and informal seed systems are seldom well connected with one another (Schöley and Padmanabhan 2017). This has in part to do with the way each seed system is organized. The formal system is a one-directional chain, starting from the breeding programs, to seed production and distribution and ending with the farmer buying the seeds as an external input. With the case of many hybrid and GMO seeds, this is done every year, with a very small number of varieties. The informal system is organized by households and communities, with seed production, breeding and finally in situ conservation happening simultaneously (Almekinders and Louwaars 2002). To transcend and integrate the two systems, the Integrated Seed Sector Development (ISSD) framework was developed, which focuses on promoting interaction and cooperation between the two systems as well as researching why farmers choose which channel, for which crops and what influences their choices (Croft et al. 2018, Louwaars and Boef 2012, McGuire and Sperling 2016).

It is through the "active management of social-ecological relations" with seeds by farmers that the formal and informal seed systems are linked (Schöley and Padmanabhan 2017). Through connecting both seed systems, farmers are able to mitigate each systems weakness and disadvantages. Farmers are not passive consumers at the end of a long seed chain, but rather actively influence the flow of seeds. The informal does not exist in contrast to the formal system, but rather it is entwined through various flows led by the farmers themselves.

2.2.5. ALV seed system in Kenya

The main constraints of ALV cultivation in Kenya is the lack of available and accessible quality seeds (Chadha et al. 2007, Pincus et al. 2018, Srinivasulu Rajendran et al. 2016). Seed insecurity remains a yearly challenge, as the demand for ALVs seeds is in many cases far higher than what the informal and formal seed market can deliver (Pincus et al. 2018). Public and private vegetable breeding is very limited in Sub-Saharan Africa (Nekesa and Meso 2018). While there has been an increase in vegetable breeding by international and regional seed companies in Kenya, these companies mostly develop hybrid seeds and do not breed improved open-pollinated seeds. Other private seed companies are active in the import and resale of seeds from Europe or South Africa, with those seeds seldomly

adapted to local conditions (Afari-Sefa et al. 2012). However, Kenyan seed companies have started to sell their own ALV seed varieties, which are predominantly used by smallholder farmers to replace their stock or to experiment with new species and varieties (Kansiime et al. 2018). The new interest of Kenyan seed companies in ALV seeds is boosted by the increase in market demand for fresh ALVs in urban areas and the emphasis by governmental and non-governmental programs to promote ALV production and their nutritional value (Croft et al. 2018).

The availability of seeds differs widely between counties and between different ALV species. 85% of farmers in the Western Kenyan counties of Kisumu and Bungoma source more than half of their seeds from their own farms (Pincus et al. 2018). However, 40% of Kisumu farmers are not able to reliably access slender leaf and in the county of Bungoma, which is only 100 km away, only 3% of farmers have difficulties accessing seeds. These discrepancies in access are unrelated to the demand of slender leaf, which is in both counties a popular leafy vegetable. The difference between counties underlines differences in the local informal seed systems and the ability of these to distribute and supply seeds (Pincus et al. 2018).

2.2.5.1. Sources of ALV seeds

Smallholder farmers in Kenya source the majority of their ALV seeds from the informal seed system (Pincus et al. 2018). ALV seeds from the informal system are in general more easily accessible, more likely to fulfill farmer preferences of local varieties, are less expensive and can have higher germination rates and yields than seeds from the formal seed system (Croft et al. 2018, Pincus et al. 2018). In Western Kenya, of the different sources in the informal seed system, self-produced seeds are the most frequent source, varying from almost 50% for cowpea leaf seeds to 75% for jute mallow seeds (Abukutsa-Onyango 2005, Nekesa and Meso 2018, Pincus et al. 2018). Seeds from farmer exchanges are the second most frequent source.

While the main source of ALVs seeds is farm-produced, 40% of smallholder farmers turn to agro-vet stores for one species of ALVs, black nightshade. Pincus et al. (2018) surmise multiple possible reasons for the preference for agro-vet stores compared to the informal seed system. On the one hand, it could be that the quality of farm-produced seeds is not sufficient, due to production difficulties and disease pressures, since 30% of farmers reported the presence of disease pressure. This does not line up though with the fact that other species have lower mean germination rates than nightshade, but were still not predominantly bought from agro-vet stores. On the other hand, it could be that farmers are more willing to invest in perceived higher quality seeds from the agro-vet stores because fresh nightshade leaves are more marketable than other ALVs. Other reasons could include farmers wanting to try new varieties or farmers importing new seeds into their seed stock to mitigate a decrease in seed quality (Pincus et al. 2018).

Farmer characteristics can influence which ALV seed source a smallholder farmer in Kenya utilizes. The location of the farmer, the species of ALV, the price of the seed and the salary of farmers all significantly influence source selection. However, other farmer characteristics are not proven to influence source selection, such as education level and age of the farmer, as well as market access (Croft et al. 2018).

2.2.5.2. Seed Quality

Farmers use different techniques to select, process and store their ALV seeds in Western Kenya. The selection of seeds is done by either choosing healthy plants (56% of households), random plants (19%), or by the maturity of the pods (24%). Seed storage lasts between 6 and 24 months depending on the species and environmental conditions. The seeds are either stored in a plastic pot with wood ash (63%), or are treated with wood ash first and then stored in a tin (27%), bottle (9%) or polythene bag (2%) (Abukutsa-Onyango 2005).

For farmers to increase their ALV production, quality seeds are a key resource. However, germination and yield rates of ALVs are the major limiting factors in quality seeds (Afari-Sefa et al. 2012, Croft et al. 2018). On the one hand, smallholder farmers who save, exchange or sell their own seeds on the market do not always have the necessary knowledge, experience, or training on how to select, process and store seeds to maintain quality (Pincus et al. 2018). On the other hand, seeds accessed from the formal seed system are shown to have lower germination and yield rates (Croft et al. 2018). To improve seed quality and support farmers in their seed production endeavors, more information on the physiological characteristics and what they entail for seed production is needed. But as with many minor and underutilized crops, there is a lack of literature on the topic. Published research has only been done on spider plant and amaranth (Pincus et al. 2018).

The demands of quality ALV seeds differs greatly between species, since ALVs come from many different plant families. Spider plant, African nightshade and jute mallow all have poor germination and dormancy problems attributed to the physiology of the seeds and the presence of growth inhibitors and parasites. With seed treatment, the germination rate can significantly improve. However, slender leaf, cowpea and amaranth do not in general have high demands regarding seed health and germination, with slender leaf having over 90% germination rates after 5 years of storage (Abukutsa-Onyango 2005).

While farmer-produced seeds are often thought to have poor-quality, since they do not undergo a regulatory procedure, the germination rate and yield may be higher than seeds sourced from formal sources. Around 40% of ALV seed samples collected in western Kenyan were shown to have a germination rate of 70% or above (Pincus et al. 2018). When measuring seed germination, amaranth seeds from informal sources had a 148 % higher germination rate, while black nightshade had a 190% higher germination rate than seeds from formal sources (Croft et al. 2018). Additionally, the fresh weight (yield) from amaranth seeds from the informal sector was 57% higher than formal seeds, while nightshade yield did not show any significant difference between the two seed sources. However, yield from one year does give information about pest or disease resistance, which could be higher in formal seeds (Croft et al. 2018).

2.3. African Leafy Vegetables, Gender and the Seed System

> “Gender is a key factor in the division of labor, rights, and responsibilities and thus is tightly bound up with the management of local ecological systems.” (Ferguson 1994)

Researchers have historically collected data from the men of the household, excluding women and their perspectives, knowledge, and experience. Men are seen as the representatives of the households, thereby ignoring intra-household variability and oftentimes undermining women’s position in the household as well as in society. Only recently have studies begun to differentiate between men and women, understanding the different gendered knowledge and perspectives in a household (Chambers and Momsen 2007).

While more and more agricultural research and development includes or even focuses on women, the intersectionality, i.e. the intersection of social identities, is rarely taken into account. Little attention is given to different social factors, such as age, gender, class, ethnicity, etc. when planning and implementing programs. Changes in power dimensions through interventions in systems are not often thought through, with unintended consequences. All this stems from an technocratic viewpoint, where sociocultural and political contexts of agriculture are ignored (Ferguson 1994). Utilizing a gendered perspective in agriculture and in particular seed systems highlights the gendered social organization of labor and power, which underline agricultural practices and knowledge (Schöley and Padmanabhan 2017).

2.3.1. Gender and ALV cultivation

ALVs in western Kenya are traditionally cultivated, handled and marketed by women, supporting women's rural livelihood (Nekesa and Meso 2018, Pincus et al. 2018). Around 80% of the actors along the ALV supply chain in Kenya are women (Weinberger et al. 2011). ALV production is especially important for female-led households, generating a higher share of income than male-led households (Mwaura et al. 2013). However, even while women dominate the Kenyan ALV supply chain, men who are involved earn significantly higher incomes than women. Female elderly small retailers and female elderly farmers have the lowest income in the ALV supply chain (Weinberger et al. 2011).

Labor on smallholder farms and in the household is commonly divided by gender, with women responsible for vegetable plants and spending more time interacting directly with them. Women are the ones who maintain and manage the plants, observing their growth, understanding their characteristics, and distinguishing between species and varieties. The gender division of labor leads to a "gender-asymmetric person-plant relationship", with women gaining expertise and in some cases authority when it comes to cultivating vegetables and exchanging seeds (Delêtre et al. 2011). When it comes to ALV cultivation in Kenya, men often consult female members of the household for information regarding planting and production methods, as they are seldom involved in the activities surrounding ALV cultivation (Nekesa and Meso 2018, Pincus et al. 2018)

While women in Kenya are more responsible for the cultivation, processing, and sale of small-scale horticulture, it is more likely when the vegetables are grown first and foremost for subsistence. This can change if horticulture production is commercialized, thereby generating outside income (Weinberger et al. 2011). This shows that the commercialization of agriculture can change gender dynamics in the household. Gender roles typically determine the division of labor in the household, with men involved in the commercialized areas. If certain food crops, such as ALVs, become commercialized, there is a chance that the men in the household will appropriate the work and benefits (Orr et al. 2016).

2.3.2. Gender and the seed system

The importance of women in seed production has been ignored in the past, with breeding programmers often focusing on male farmers and integrating them in research and extension activities. However, women are often essential for seed production, selection, conservation, storage, as well as sourcing seeds for their fields and for their spouses (Nkengla-Asi et al. 2020). They are often holders of agro-ecological knowledge of seeds and varieties, more able to determine seed quality and identify diseases than the male members of the household (Almekinders and Louwaars 2002, Gill et al. 2013, Nkengla-Asi et al. 2020).

The informal seed system is based on complex and diverse social systems, where kinship systems play an integral part. Depending on the marriage structure of the community, women are key actors in the informal seed system, with the inheritance of seeds and its subsequent journey to new communities crucial for the agrobiodiversity and the distribution of species and varieties (Bezner Kerr 2013, Delêtre et al. 2011, Mucioki et al. 2016, Violon et al. 2016). In eastern Kenya, seed systems are matrilineal, where seed and knowledge are passed through generations of women. Women are responsible for selecting and saving seeds and teach their daughters these practices. When a woman in the family marries, she receives seeds saved by her mother to take with her to her new family, since she will move into her husband's household (Mucioki et al. 2016). However, the influence of marriage exchanges depends on the cultural and economic importance of the crop, as well as the designated "gender" of the crop. Whether a crop is subjugated to the realm of men or of women influences which social structures come into play when seeds are exchanged (Delêtre et al.).

While matrilineal societies foster species and varietal diversity, it also reduces the ability of a community to control the seed system. The constant inflow of new species and varieties can increase

the risk of importing viruses, pests, and other pathogens. That is why some communities in Gabon purposefully restrict the exchange of germplasm between communities. This is done indirectly through the social control of women to their daughter-in-law, by prohibiting matrilineal seed exchange (Delêtre et al. 2011).

Gendered differences in the sourcing of seeds are not only constituted by kinship relations, but also reflect gendered division of labor and power, access to resources and gendered agency in institutions and the social system. Men are more active in the public sphere and have more access to formal and informal sources, especially those which are father away from the community. They are more likely to access new varieties and certified seed (Croft et al. 2018, McGuire and Sperling 2011, Mulesa et al. 2021). Female farmers are more often sidelined to the private sphere, where they access their seeds on their farm or from immediate social networks and kinship systems (Schöley and Padmanabhan 2017, Tadesse et al. 2017).

The range of mobility is an important factor influencing which seed sources are used between men and women. For example, in India men source more seed from agriculture officers and family than women, as they usually own and drive motorcycles and are more able to access a wider range of sources and interact with formal seed sources (Schöley and Padmanabhan 2017). However, the range of mobility is contextual, depending on infrastructure, social expectation etc. Contrary to the example from India, women in Cameroon source seeds from outside the village more frequently than men since they have more extensive networks outside the village which are based on kinship relations (Wencélius et al. 2016). Networks outside the village are vital in times of seed shortages (Violon et al. 2016). Additionally, women in India who are wealthier have more opportunity to leave their households and visit their kin in their native village than women from poorer and monogamous households (Wencélius et al. 2016).

However, women and men often use the same channels for obtaining seeds. The difference between them is rather the importance of each channel and the plurality of actors used in each sector. Knowledge of the seeds, their characteristics and cultivation requirements, are exchanged with the seeds. This means that the same sources used for seed exchange are often used to obtain information (Schöley and Padmanabhan 2017).

2.3.3. Household participation and decision making

> "Gender relations determine the division of labor, access to resources and decision-making power in agricultural dependent communities and households in developing countries". (Nkengla-Asi et al. 2020)

Development research and programs traditionally view households as unitarian, i.e. all members of the households have the same preferences and perspectives and all resources in the household are shared (Padmanabhan 2011). However, the neoclassical model of a household as a unitary entity is problematic since it cannot encompass different household members in different cultural contexts and their intrahousehold dynamics (Wencélius et al. 2016). This theoretical and methodological approach ignores gender asymmetry in the household, which, produced by patriarchy, are central to the women's bargaining power (Dolan 2001). Understanding women's decision making ability, and therefore access to and control over productive assets, is essential for gender equality (Nkengla-Asi et al. 2020).

Household participation and decision making influences the bargaining power of the individuals in the household, thereby determining the resources that each individual has access to (Doss 2013, Quisumbing 2003b). The extent of decision making reflects intrahousehold power dynamics, reflecting who has control over what. Further distinction can be made between strategic, operational, and financial control. Strategic control is the ability to choose how resources are allocated, i.e., which crops receive which inputs. Operational control describes how resources are managed, such as which crops

are chosen. Finally, financial control is the power to decide how the income from a crop is used (Orr et al. 2016).

Intrahousehold power dynamics influences who benefits from commercialization and the resulting increase in income. Four examples from Kenya illustrate how the commercialization of certain crops influenced the household. The first example concerns horticulture production (specifically French beans), which is historically the responsibility of women, with cultivation geared towards household consumption and sale at local markets. However, through the intensification, commodification and export orientation of horticulture, men have appropriated production, resource allocation, and derived income, thereby depleting women's control in the household and undermining gender equity (Dolan 2001). The second example concerns the banana sector, where commercialization has led to an increase in male control over banana production and revenues. The loss of income for women in the household negatively affected dietary quality, as income controlled by women is more likely to be spent on food. However, when women were members of a farmer group, they were not only more able to withstand male appropriation, but could also increase their control of household income (Fischer and Qaim 2012). The third example involves ALV seed production. While ALV seed production was perceived to be of equal importance to both men and women, how much they earned from seed production differed, depending on who was the primary decision maker. If this was a women, the average income from seed production was lower than if the primary decision maker was a man (Pincus et al. 2018). Finally, the fourth example involves three western Kenyan communities where ALVs are cultivated. In Luhya (in Vihiga County) and Luo, women are the ones most often growing, processing, and marketing ALVs. However, in the Kisii district, where ALV cultivation is more commercialized, the division of labor has changed, with men more involved in ALV cultivation (Abukutsa-Onyango 2005).

While the four examples mentioned above describe intrahousehold conflicts, the commercialization of crops cultivated by women can also be perceived as an opportunity for cooperation. Whether commercialization leads to cooperation or conflict in gender dynamics depends on the specific historical and cultural contexts of women's bargaining power (Orr et al. 2016). Resources in the household are not distributed equally, but rather favor men. Thereby, interventions aimed at improving the situation of women must increase the resources controlled by women, thereby increasing their bargaining power in the household. This increase of women-controlled resources and decision making increases yield or leaves yield unchanged, increases resource allocation towards education and importantly, improves women and children's health and nutrition (Quisumbing 2003a).

3. Research Aims and Questions

This thesis is embedded in the project from Bioversity International in Kenya *'Improving access to and benefits from a wealth of diverse seeds to support on-farm biodiversity for healthy people in resilient landscapes'* (P2). It has the applied purpose of supporting ALV cultivation, ALV community seed bank initiatives and on-farm ALV seed conservation projects in Kenya. This thesis has three main research aims, with eight research questions:

Aim I: Identify which ALVs are cultivated by smaller holder farmers in Vihiga County, Kenya and what factors influence cultivation.

RQ1: Which ALVs are cultivated by smallholder farmers in Vihiga County, Kenya?
RQ2: How does market access, household income and assets, and household demographics influence the cultivation of ALVs?

Aim II: Identify the sources of ALV seeds and the influencing variables in the informal ALV seed system.

RQ3: Which sources do smallholder farmers use for accessing and distributing ALV seeds?
RQ4: Which ALV species are exchanged in farmer-to-farmer seed exchanges?
RQ5: What are the relationships of farmers to their supplier or procurer of ALV seeds in farmer-to-farmer seed exchanges?
RQ6: How does market access, household income and assets, household demographics and the cultivation of ALVs influence the informal ALV seed system?

Aim III: Describe the extent to which women are able to participate in and make decisions about the cultivation of ALVs.

RQ7: To what extent are women able to participate in and make decision about the cultivation of ALVs?
RQ8: How does the extent of participation and decision making by women in the cultivation of ALVs influence the cultivation of ALVs and the informal ALV seed system?

4. Methods

This thesis uses data from a baseline survey done within P2, which builds on the previous project also implemented by Bioversity International: '*Participatory approaches to improve dietary diversity through food systems innovations in Vihiga County, Western Kenya*' (2014-2016) (P1). In P1, five control communities and 5 intervention communities were selected. The intervention consisted of a diversification of farms and diets. One conclusion of P1 was that ALV seeds are a major limitation for ALV cultivation (Bioversity International 2019). Additionally, six ALV species were signaled out in the diagnostic survey for their importance in the communities. The 5 intervention communities are Tier-1, the 5 control communities Tier-2. The 5 new communities selected in P2 are Tier-3.

For this thesis, the study design is observational, with no active intervention with the study population but rather an observation of the situation. The structure of the observational research is cross-sectional, comparing multiple subsections within a population (Newing and Eagle 2010). In general, the methods I used are deductive, i.e., there was a specific research question for which data was collected and the data was evaluated to look at the relationship between specific, pre-defined variables.

4.1. Study Region

The baseline survey was done in 15 sublocations in Vihiga County, which is located in Western Kenya, in the Lake Victoria Basin. The Tier 1 sub-locations include Mambai, Essunza, Masana, Itumbu and Wanondi. The Tier-2 sublocations include Emanda, Vigulu, Emaloba, Mwitubwi, and Ebunangwe. The Tier-3 sub-locations include Bugina, Ebahando, Munoywa, Muhudu, and Senende.

Vihiga county lies between 1500 and 1900 meters ASL and is in the upper midland agroecological zone, with an annual mean temperature of 18.5 to 21.0°C and an annual mean rainfall of 1800mm to 2000mm. The rainfall is bimodal, with a main rainy season from April to June, and a short rainy season from September to November. The soils in Vihiga County are predominantly a combination of combisols, lithosols, and well-drained nitosols, with a low fertility due to continuous cropping with annuals and leaching over the past decades (Waithaka et al. 2007).

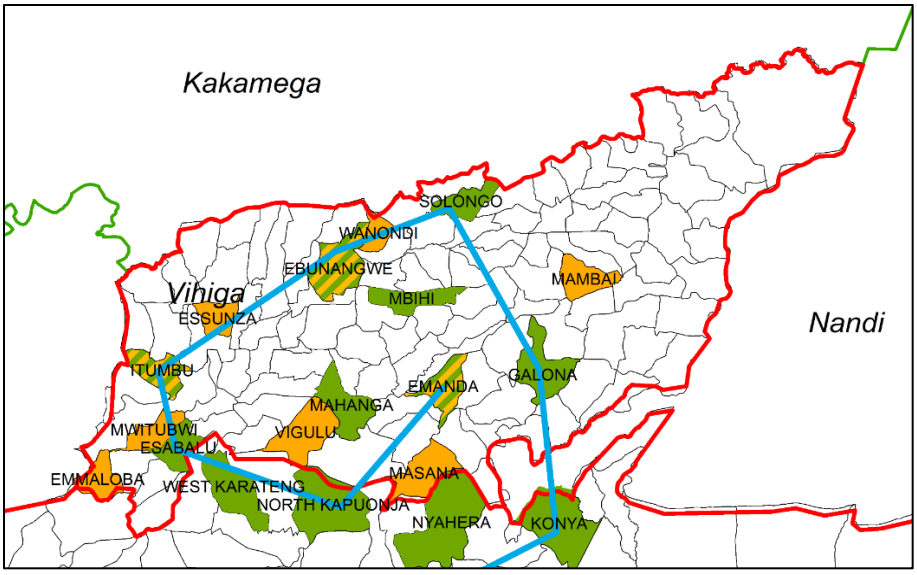

Figure 1: 15 Sublocations used in the baseline survey in Vihiga County, Kenya.

In the Vihiga county, smallholder farmers own between 0.5 and 5 hectares of agricultural land (Abukutsa-Onyango 2005), with an average farm size of 0.86 hectares (Waithaka et al. 2007). While farmers have secure land rights, farm sizes have been declining in the past years (Kiptot et al. 2006). Farmers are involved in a mixed farming and livestock cropping system, with a low-external-input subsistence production. The main subsistence crop is maize (*Zea mays L.)* intercropped with beans (*Phaseolus vulgaris L.*) (Kiptot et al. 2006) and the main livestock kept is local zebu (Waithaka et al. 2007). Other major crops include cassava, green grams, finger millet, sweet potatoes, soya beans, sesame, groundnuts, bananas, and various African vegetables, while livestock production can include dairy cattle, poultry, sheep and goats (Pincus et al. 2018). The main cash crops are sugarcane, coffee, and tea. Animal manure is the main source of fertilization, however the quantity and quality are oftentimes insufficient for maintaining soil fertility. Inorganic fertilizers are rare due to lack of sufficient funds by smallholder farmers (Waithaka et al. 2007).

4.2. Data Collection and Storage

This thesis uses data from a quantitative baseline survey done within P2 in 15 sublocations in Vihiga County. The household and agricultural practices questionnaire was done in 2018. Eligible households were those with at least one child within the age of 6 – 23 months and a woman in the reproductive age group (15 – 49 years). Of all the households, a random sample was selected using the RAND function in MS excel. The number of households interviewed was 446. However, due to missing data and incorrect collection, 15 respondents were taken out of the final analysis, with the final sample population coming to 431 respondents (n=431). Data collection consisted of a semi-structured household and agricultural practices questionnaire, seen in the appendix, chapter 11.2. I used three parts of the questionnaire: demographic and socio-economic characteristics, household agricultural practices and farm diversity, and household decision making. All the quantitative data was entered in MS excel.

4.3. Study Population

Vihiga County has a population of 590,013 people distributed within 143,365 households. The average household size is 4.1 people per household. Vihiga county is a small county, consisting of only 563.8 square meters. However, Vihiga county has one of the highest population densities in Kenya, with 1047 people per square km (Kenya National Bureau of Statistics 2019). The average age of the household head is 51.1 years and 41% of households are managed by males (Waithaka et al. 2007). 87.2% of households are involved in crop farming, contributing to 64% of the Vihiga county's income. The poverty level is 41% (45.9% at national level). The dominant ethnic group is the Luhya, with subtribes such as the Maragoli, Banyore, Tiriki and Terek.

4.3.1. Household demographic results

The survey partly targeted the female household head or the spouse of the male household head as respondents. Eligible households were those with at least one child within the age of 6 – 23 months and a woman in the reproductive age group (15 – 49 years). Regarding age, the mean age of the respondents was 29.16 years, ranging between 17 and 78 years. While the range is high, 50% of the women interviewed were between the age of 23 and 33 years.

Various social-demographic characteristics, such as relationship to household head, marital status, marriage relationship and education level, of the women were collected during the interview (

Table 5). Of the 431 women who participated in the survey, 66.8% of women were the spouse and 14.6% the daughter to the household head. Only 12,5% of women considered themselves the household head. The overwhelming number of women were in a monogamous marriage relationship structure (97%) and were married (81.7%). Very few women were widowed (2.5%) or separated (3.7%), which is most likely attributed to the fact that women with a child between the age of 6 and 23 months were targeted. Regarding education, over half of the women had either attended or finished upper primary school, while around one third of the women attended or finished high school. Only about 5% of the women attended college or university and about the same amount attended vocational schools.

4.3.2. Economic assets and income

Sources of income that stem from on-farm production include the sale of grains, legumes/pulses, roots or tubers, fruits, ALVS, other vegetables (non-ALVs) and animals or animal products (Table 6). More than half of the households did not have any source of income stemming from on-farm production (53.4 %), with the average mean number of on-farm sources of income at 0.96 sources. Of all the seven on-farm sources of income mentioned, the sale of ALVs and other vegetables (non-ALVs) was the most frequent. 22% of households received income from the sale of ALVs, while 23.2% of households sold other (non-ALV) vegetables. The sale of animals or animal products was also an important source of income, with 18.6% of households mentioning it as a source of income.

Off-farm sources of income include earnings as a petty trader, as a mechanic, as a casual laborer (with daily wages), as a hairdresser, as a boda-boda driver, as a metal worker or carpenter, as an employee (regular salary), as well as earning by sale of own produced or gathered goods and crafts, by income from remittances, by income from cash transfer programs, and finally earning from non-specified off-farm sources (Table 6). 28.1% of households had no off-farm source of income, while 56.1% had only one source of off-farm income. In average, households had 0.9 sources of off-farm income. The most frequent occupation outside farming was a casual laborer (32.9%), followed by petty trader (16.2%) and an employee with a regular salary (10.6%).

Whether or not the off-farm source of income is higher than that of the sale of on-farm production is also relevant (Table 6). Few of the off-farm sources of income generated more income than that of farming, with 80% of households not earning more from off-farm sources of income compared to farming. Only 7.9% of households reporting earning more as a casual laborer than from farming, while the other sources were of even less importance.

The ownership of 24 different household assets was used to estimate the wealth of the household. The most frequently owned household asset was the hoe (91.2%), followed by the radio (74.7%), mobile (not smartphone, 72.4%) and a sofa set (52.9%) (Table 7). Regarding farming equipment, 40.4% of households had a spade or shovel, 20.6% a wheelbarrow, and less that 3 % had a water pump or a plough. The average amount of household assets was 5.82, ranging between 0 and 16 assets (

Table 8).

The time required to reach a market by foot for purchasing or selling food items not only differed greatly between households, but many households either did not go to the market in the first place or in general did not sell produce. It took the households between 1 and 180 minutes to reach a market to purchase food, with an average mean of 42.82 minutes. Only 92 households mentioned selling their produce at a market, with the time needed to reach this market ranging between 1 and 120 minutes, with an average mean of 37.59 minutes.

4.4. Data Analysis

4.4.1. General approach

To prepare the data for analysis, the data was cleaned, and new count variables were created in MS excel. Data cleaning included checking for missing data, transforming qualitative data into discrete quantitative variables, deleting variables which had high levels of inconsistency, and changing crop and species names into English without varietal differences, as the analysis of ALVs is on a species level. In addition, new count variables were created, which included sum-indexes of household assets, household income, and farmer-to-farmer seed exchanges.

For data analysis, I used descriptive and inferential statistical tests in the software SPSS (IBM 2016). The selection of analyses was based on Bühl 2008 and Newing and Eagle 2010. In terms of descriptive statistics, this thesis includes frequency tables, means for interval and count data, and bar charts to illustrate nominal data. In terms of inferential statistics, all statistical tests were used with a level of $p < 0.05$ to determine statistical significance. Numerical data was tested with a two-tailed spearman rank correlation, as the data was not nominally distributed. The strength of Spearman's correlation coefficient rho (r_s) was interpreted as follows: very weak ($r_s<\pm0.2$), weak ($r_s=\pm0.2$-±0.4), moderate ($r_s=\pm0.4$-±0.6), strong ($r_s=\pm0.6$-±0.8), very strong ($r_s>\pm0.8$).

To compare categorical (nominal and ordinal) variables, I used a multivariate cross-tabulation with a chi-square test of independence. If the basic assumptions of the Chi-square test were violated, I applied a Fisher's exact test. Additionally, I used a Bonferroni-adjusted post-hoc analysis for the multivariant chi-square test to account for the significant comparisons between sub-groups and a Cramer's V measurement to test the strength of association between variables. The strength of Cramer's V was interpreted as follows: no or very week (>0), weak (>0.05), moderate (>0.10), strong (>0.15), very strong (>0.25). Finally, I used a Poisson regression model and a negative binomial regression model for the count variables to determine which of the independent variables have a statistically significant influence on the dependent variables. I used a negative binomial regression model if the dependent variable did not show a Poisson distribution, in other words when the count data was over-dispersed, with a variance larger than the mean.

4.4.2. Analysis of influencing factors on ALV cultivation and seed system

To determine if and how various factors affect the ALV seed system, the ALV seed system was first measured through four variables: ALV seed sources mentioned in total per household, the diversity of different seed sources used per household, the total number of farmer-to-farmer seed exchanges in and outside the village, and the relationship between farmers in farmer-to-farmer seed exchanges. Second, the independent variables were defined by market access (the time needed to reach the market by foot to purchase food items, and income from sale of ALV products), household income (the number of sources of on-farm income, the number of sources of off-farm income and the total number of household assets), household and women demographics (sublocation of household, age, marital status, relationship to household head and level of education of the woman) and number of ALV species cultivated.

To determine the participation of women in ALV cultivation, as well as their extent in making decisions in the household, six questions were surveyed. These include who decides whether to cultivate ALVs,

who is responsible for ALV cultivation, who decides whether to sell ALV produce or products, who decides how money from the sale of ALVs is used, who makes the final decision which ALVs are cultivated and finally, to what extent can the woman in the household make her own personal decisions regarding which ALVs are cultivated. These questions were only answered by those households who cultivate ALVs, i.e. around 90% of households (n=431). In addition, only 25.7% households sell their ALV produce or products in the last 12 months, reducing the number of answers regarding sale of ALVs to 87 households.

To determine the extent of participation and decision making by women in the informal seed sector, the same dependent variables were used as before: ALV seed sources mentioned in total per household, the diversity of different seed sources used per household, the total number of farmer-to-farmer seed exchanges in and outside the village, and the relationship between farmers in farmer-to-farmer seed exchanges. In addition, the sources for the individual ALV seeds were also analyzed with women participation and decision making.

4.5. Ethical Questions

This study was non-invasive and participatory, involving local stakeholders and fostering community engagement and ownership. Written consent was obtained from all participants before the questionnaire was used and a small compensation of 2 packets of 500ml milk was given at house visits. The names of the participants were only collected for the purpose of identification, with each participant assigned a unique ID which was used for data entry and analysis. No names were disclosed at any point beyond field collection. The study was approved by the Ethical Review Board and registered with the ISRCTN (International Standard Registered Clinical/soCial sTudy Number) registry.

4.6. Study Limitations

The major limitation of this thesis is that I did not collect the data myself and I do not have any personal experience of the situation in the field, making it in some cases difficult to properly understand and analyze certain data. As I did not participate in the data collection, I am obligated to trust in the quality of the data collection process since I had no influence on the process. This proved to be difficult when cleaning the data because there were major inconsistencies with certain variables, such as land size of the household, leaving me unable to analyze those variables. Different languages and units were a constant challenge, as well as inconsistencies in how to categorize missing data. Finally, my study is synchronic, in other words it is a snapshot of the situation (Newing and Eagle 2010). It consists of data collected in only one year, which can be affected by factors I cannot know.

The sample population and the eligibility of households participating in the baseline survey are another limitation to the study, as they were chosen in accordance with the aims of P2. The data I used for analysis stemmed from an extensive baseline survey, which had a broad aim of collecting data for improving diets of households through ALV cultivation. Due to this nutritional focus, eligible households were those with at least one child within the age of 6 – 23 months and a woman in the reproductive age group (15 – 49 years). This limits the results and conclusions of my study, as the sample population does not intend to reflect the population of Vihiga county.

5. Results

5.1. Cultivation of ALVs

5.1.1. ALV Species Cultivated

Over 88% of the 431 smallholder farmers surveyed in Vihiga County cultivate ALVs (Figure 2). Ten different ALV species have been cultivated over the last two years: cowpea leaf, black nightshade,

slender leaf, spider plant, jute mallow, amaranth, pumpkin leaf, Ethiopian kale, vine spinach and cassava leaf. Households cultivate an average of 2.13 different species of ALVs. The number of different ALVs cultivated range from zero species (49 households, or 11.4%) to nine species (only one household, or 0.2%). Over 70% of households cultivate either one, two or three ALV species.

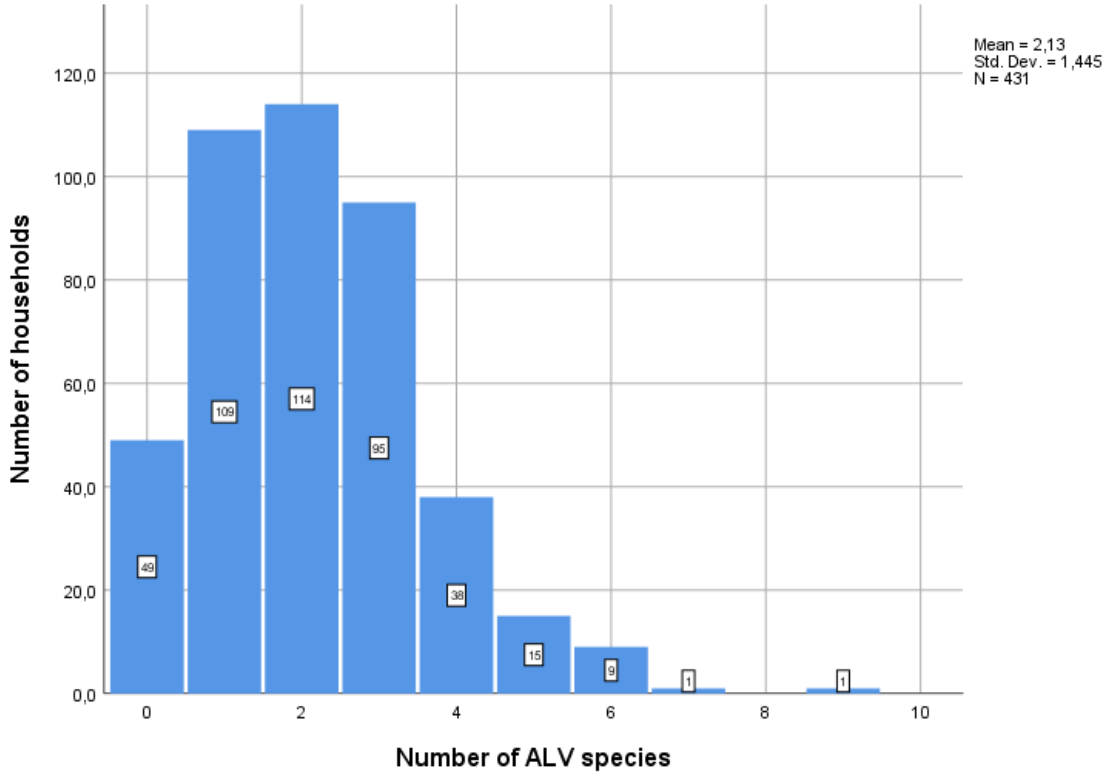

Figure 2: Number of households cultivating specific number of African Leafy Vegetable (ALV) species in the last two years (n=431).

Certain ALV species are more frequently cultivated by households than other ALV species (Table 1). By far the most frequently cultivated ALV is cowpea leaves, with 74.7% of households cultivating cowpea leaves. Slender leaf, jute mallow and Ethiopian kale follow, with just under 1/3 of households reporting cultivation. Black nightshade (18.8%), pumpkin leaves (12.5%), spider plant (9.7%) and amaranth (7.7%) are less frequently cultivated. Vine spinach and cassava leaves are rare, with less than five households reporting that they cultivate those species.

When focusing on those who do cultivate ALV species, the mean number of years cultivating range between 2.00 and 8.82 years (Table 1). The highest mean year of cultivation between species is jute mallow (mean: 8.82 years), followed by cowpea leaves (mean: 8.29 years). The high standard deviation of both species indicates that there is a wide spread of years cultivating in the sample. The remaining species (excluding cassava leaves and vine spinach) have been cultivated a mean average of 3.42 to 4.91 years.

Table 1: Percentage of households (n=431) cultivating a certain (African Leafy Vegetable) ALV species and mean duration of cultivation of that species in years.

Cultivation of ALV species	Percentage of households	Mean cultivation in years
Cowpea leaves	74.7%	8.29
Slender leaf	29.9%	4.26
Jute mallow	28.3%	8.82
Ethiopian kale	28.3%	4.91
Black nightshade	18.8%	4.58
Pumpkin leaves	12.5%	3.42
Spider plant	9.7%	4.10
Amaranth	7.7%	4.63
Cassava leaves	0.9%	2.00
Vine spinach	0.7%	2.33

The importance of the different ALV species cultivated is measured by ranking the contribution of the ALVs for household income and food security from one to five. A low contribution is ranked with one, while a high contribution is ranked with five. Those households that either do not consume or do not sell their ALV produce were not asked to rank the contribution of the crop. All the ALVs are ranked higher individually and collectively for food security than for income, with the lowest ranked ALV for food security (slender leaf at an average mean of 3.02) still considerably higher than the highest ranked ALV for income (amaranth at an average mean of 1.62) (Table 2). In addition to being the highest ranked ALV for income, amaranth also has the highest mean rank for food security (3.62). Cowpea leaves, which is the most frequent ALV to be cultivated, has the lowest contribution rank for food security (3.02). The low rank of ALVs for income security is also visible in the low percentage of households who have sold their ALV products or produce in the last 12 months. Only 25.7% of households have sold ALVs in the last year, while the rest of the households did not sell any ALVs.

Table 2: Contribution rank (1 low to 5 high) of African Leafy Vegetables (ALVs) cultivated for household income and food security in order of highest mean contribution rank (n=431).[1]

ALVs cultivated for	Frequency of answers	Mean contribution rank
Food security		
Amaranth	34	3.62
Spider plant	42	3.38
Black nightshade	76	3.25
Pumpkin leaves	47	3.23
Ethiopian kale	120	3.19
Slender leaf	122	3.18
Jute mallow	108	3.08
Cowpea leaves	313	3.02

[1] Vine spinach and cassava leaves were excluded due to low number of respondents cultivating these two species.

Household income		
Amaranth	24	1.62
Pumpkin leaves	27	1.59
Cowpea leaves	212	1.59
Spider plant	32	1.53
Slender leaf	86	1.50
Black nightshade	54	1.50
Jute mallow	77	1.47
Ethiopian kale	86	1.41

5.1.2. Characteristics of women and households cultivating ALVs

To understand who is cultivating ALVs, the households interviewed are categorized into five groups: those who have not cultivated any ALVs in the past two years and those who have cultivated either one, two, three or four or more different species of ALVs (Table 3). There is a significant weak positive correlation between the age of women and the number of ALV species cultivated (r_s: 0.32, $p<0.01$). The average age of women who do not cultivate any ALV species or who cultivate one ALV species is 27.94 years. As women get older, they are more likely to cultivate more ALV species, with the average age of women who cultivate four or more species 30.33 years.

Various income indicators significantly influence if households cultivate ALVs, as well as the diversity of ALV species cultivated (Table 3). There is a weak positive correlation between the number of different on-farm sources of income and the number of ALV species cultivated (r_s: 0.225, $p<0.001$). The mean number of different on-farm sources of income is 0.55 sources for those households who do not cultivate any ALV species. This mean increases with each additional species cultivated to an average mean of 1.28 sources of on-farm for those households who cultivate four or more ALV species. The number of off-farm sources of income showed the opposite tendency, with a very weak negative correlation (r_s: -0.143, $p<0.01$). The average mean of off-farm sources of income for households who do not cultivate any ALVs was 1.08 sources and decreased with each additional ALV cultivated. For those who cultivated four or more ALV species the average mean number of off-farm sources of income was 0.77 sources. Finally, the average mean number of assets that each household owned had a very weak positive correlation (r_s: 0.093, $p<0.05$) to the number of ALV species cultivated.

The access to markets does not significantly influence whether households cultivate ALVs (Table 3). Access to markets for purchasing food items and selling produce is measured by the length of time in minutes needed to walk to the market. The length of time needed to reach the market to purchase food items in almost all cases greater than the length of time needed to reach the market to sell produce. The average mean amount of time needed to reach the market for purchasing food items ranges from 41.00 to 44.33 minutes. For those who cultivate four or more ALV species, the average mean time to reach the market for purchasing food items is less (41.23 minutes) than the average time needed to reach the market to sell produce (47.67 minutes). Finally, while the total value of ALVs sold at the market did decrease with each addition ALV species grown, this result was not significant.

Table 3: Average age, income, and market access of women and households grouped by number of African Leafy Vegetable (ALV) species cultivated (n=431 households, f is frequency of answers).

	Total Number of ALV species cultivated						
	No ALV species cultivated	1 ALV species cultivated	2 ALV species cultivated	3 ALV species cultivated	4 or more ALV species cultivated	Spearman Correlation to total number of ALV species cultivated	
	mean					C. Coeff. r_s	Sig.
Age in years of women (f=431)	27.94	27.94	29.60	29.85	30.33	.132**	.003
Number of sources of on-farm income (f=431)	0.55	0.66	0.99	1.24	1.28	.225**	.000
Number of off-farm sources of income (f=431)	1.08	0.94	0.92	0.81	0.77	-.143**	.001
Number of off-farm sources of income with higher income compared to farming (f=431)	0.20	0.25	0.25	0.26	0.17	-.019	.348
Total number of household assets (f=431)	5.06	5.72	6.01	5.62	6.52	.093*	.026
Time by foot to reach market for purchasing food items in minutes (f=425)	41.00	44.33	44.08	41.60	41.23	-.001	.494
Time by foot to reach market for selling produce in minutes (f=92)	38.29	38.41	31.75	36.17	47.67	.040	.353
Total value (in KES) of ALV products/produce sold in the last 12 months (f=60)	0	6,066.67	6,041.67	5,536.36	4,805.00	-.100	.224
Total number of ALV species cultivated (f=431)	0	1.00	2.00	3.00	4.64		

Correlation is significant at the 0.05 level (2-tailed).*

Correlation is significant at the 0.01 level (2-tailed).**

5.2. ALV Seed System

5.2.1. Sources of ALV seeds

Smallholder farmers utilize many different sources to obtain ALV seeds needed for cultivation. Seeds of the six most common ALV species (black nightshade, spider plant, amaranth, cowpea leaves, jute mallow, and slender leaf) are obtained from the following eight sources: own seed, neighbors/fellow farmers/family members, local market, extension services, seed companies or traders, farmer groups, NGOs, and other sources. Of the 431 households, 14.6% did not mention any sources, which means they most likely do not cultivate ALVs.

Over 90% (965 seed sources mentioned by all households, f=965) of the seeds from the six ALV species are obtained from only three main sources in the informal seed system: the local market, own seeds, and from neighbors, fellow farmers or family members. The most frequent source by far is the local market, with 87.5% of households (n=431) mentioning the local market as a main source for the different ALV seeds. This is followed by the use of own seeds, at 29.3%, and sourcing seeds from neighbors, fellow farmers and family members, at 11.1%. Formal seed sources are of marginal importance. The diversity of sources utilized is limited, with most households (62.2%) utilizing just one of the eight seed sources for all six ALV species and only 18.1% of households utilizing two different sources.

The six main ALV species vary greatly not only in the frequency with which households source the seeds (Figure 3), but also in the sources utilized for obtaining seeds (Figure 4). Of the 431 households questioned, over two/thirds of the households source cowpea leaf seeds, and over half of the households source jute mallow as well as slender leaf seeds. The number of households sourcing different ALV seeds is similar to the cultivation rates of ALVs (Table 1).

Smallholder farmers source their ALV seeds predominantly from the informal seed system, irrespective of the species of ALV (Figure 4). With the exception of amaranth, all seeds of the six ALV species are predominantly sourced from the local market. Over 80% of cowpea leaf and spider plant seeds are sourced from the local market. Amaranth has the highest percentage of seeds sourced from own production, at 36.1%, followed by jute mallow and slender leaf. Less than 10% of cowpea leaf seeds are produced at home. When comparing ALV species, the species that are sourced the most from neighbors, fellow farmers or family members percentage wise is black nightshade, at almost 20%.

The formal seed system is of little relevance for smallholder farmers when obtaining ALV seeds (Figure 4). Black nightshade is the only ALV species sourced from extension services and jute mallow is the only ALV species to be sourced from a seed company or trader. Less than 2% of black nightshade seeds are sourced form farmer groups and less than 1% of jute mallow and slender leaf are sourced from farmer groups and from NGOs.

The source of ALV seeds is significantly dependent on the individual ALV species (X^2=251.422, $p<0.001$), with a strong association (Cramer's V= >0.5). A post-hoc comparison of all sources of seeds with all ALV species reveal that certain pairs of variables are highly significant in their relationship. Black nightshade has significantly higher rates than expected for the sources neighbor, fellow farmer or family members and extension services; amaranth has significantly higher rates for the sources own seed and other, as well as significantly lower rates for the source local market; and finally, cowpeas has significantly lower rates for the source own seeds and other, while having significantly higher rates for the source local market.

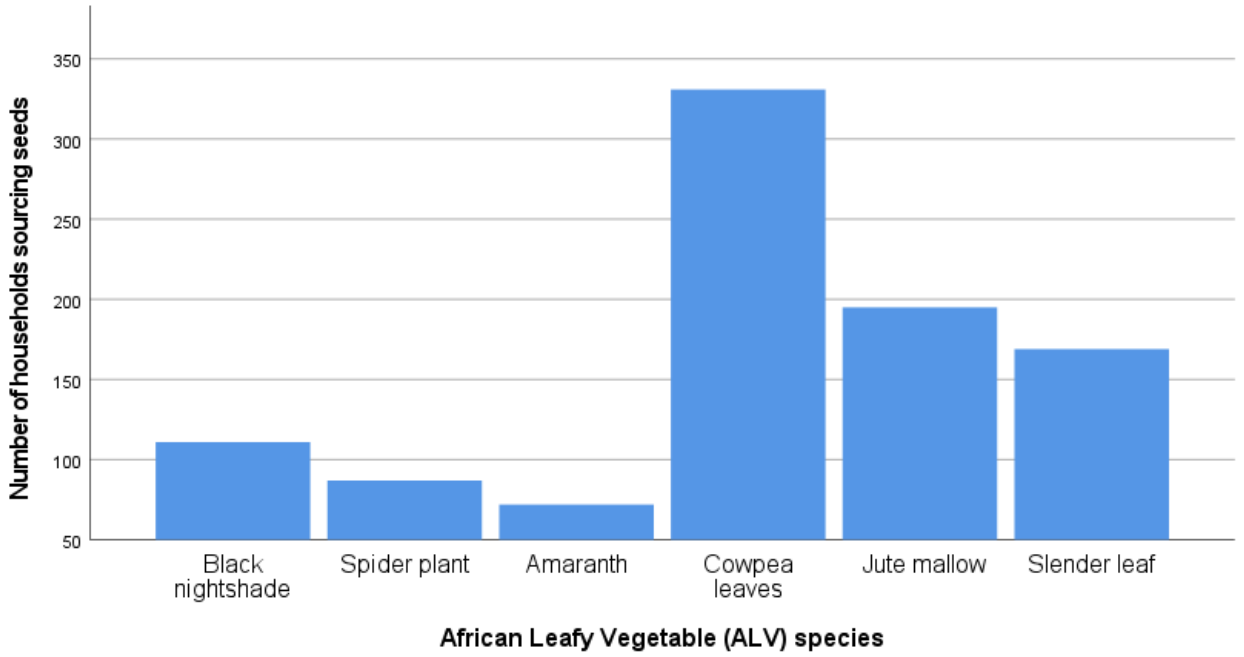

Figure 3: Number of households sourcing African Leafy Vegetable (ALV) seeds by species (n=431).

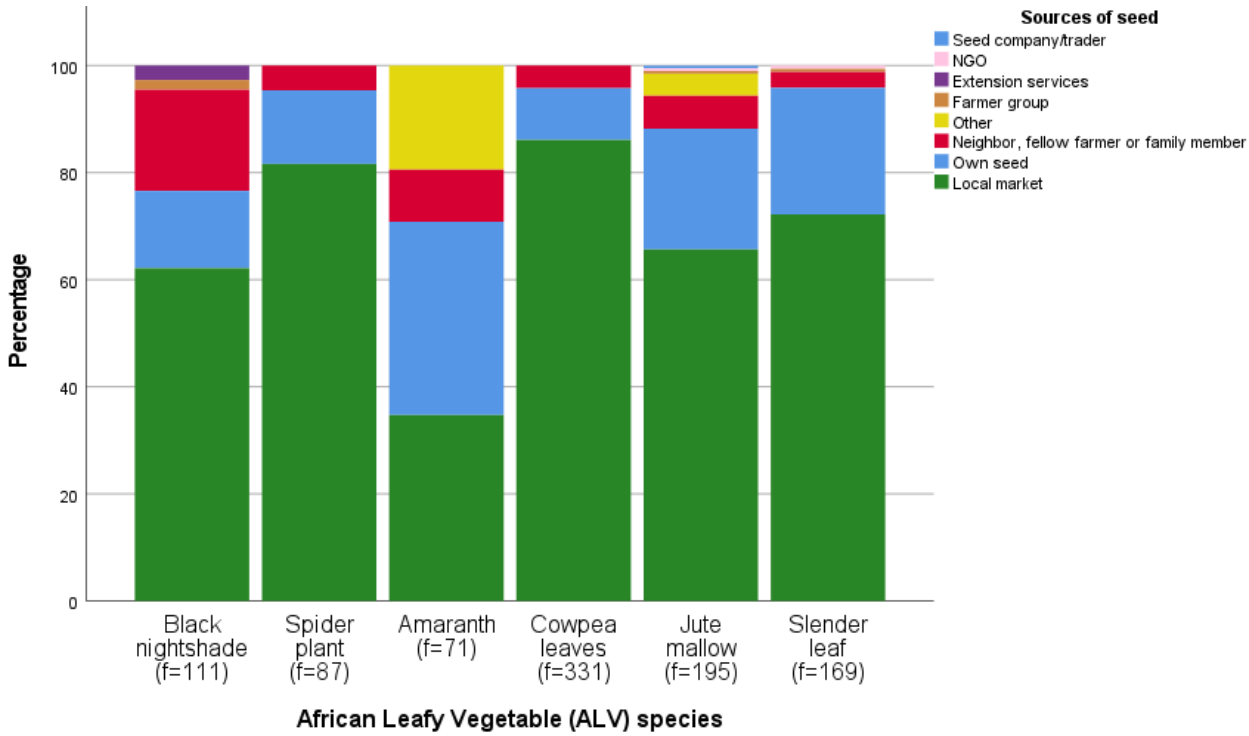

Figure 4: Seed sources utilized by smallholder farmers for African Leafy Vegetable (ALV) seeds by species. Results shown in percentages (n=431, respective f per species is 100%).

5.2.2. Farmer-to-Farmer ALV seed exchanges

Farmer-to-farmer seed exchanges of ALVs are an important source of ALV seeds, with 34.6% of households reporting that they have exchanged ALV seeds with one or more farmers in the last year. These farmer-to-farmer seed exchanges consist of either obtaining or supplying other farmers with ALV seeds, either inside or outside the home village. While over a third of the farmers exchange seeds with other farmers, this is most often done with only one or two other farmers.

Exchanges in the village are more frequent than exchanges outside of the village (Figure 5). Moreover, 1/3 of farmers supply other farmers in their village with ALV seeds. In comparison, 19% of households obtain ALV seeds from inside the village and only 8.4% obtain seeds from outside the village. The least frequent farmer-to-farmer ALV seed exchange is supplying seeds to other farmers who reside outside the village, with only 5.1% of households mentioning they had done this in the last year.

Farmer-to-farmer seed exchanges are predominantly held between farmers who are related to one another, either by birth or blood, by marriage or by tribe. Only 27.7% of the seed exchanges are done between farmers who are not related. The most common relationship between farmers is by tribe, consisting of 31.4% of seed exchanges, followed by birth or blood (25%) and by marriage (15.9%). However, this is not the case when only exchanges outside and inside the village are signaled out. There is a strong significant association (X^2=14.252, $p<0.01$, Cramer's V= 0.216) between the relationship of farmers in farmer-to-farmer seed exchanges inside and outside the village. The relationship with farmers outside the village influences if farmers exchange seeds. Over 40% of farmer-to-farmer seed exchanges outside the village are done between farmers related by birth or blood to one another, compared to a mere 20% in the village.

Similar to Figure 3, which shows the frequency of households sourcing different ALV species, the most frequent seed species exchanged are slender leaf, cowpea leaf, and jute mallow (Figure 5). However contrary to the general sourcing of seeds, slender leaf seeds (and not cowpea leaves) are exchanged the most between farmers (25% of exchanges). Amaranth is seldom exchanged in the village and never exchanged with other farmers outside the village. A chi-square test did not prove that ALV species influence whether farmer-to-farmer seed exchanges are inside or outside the village.

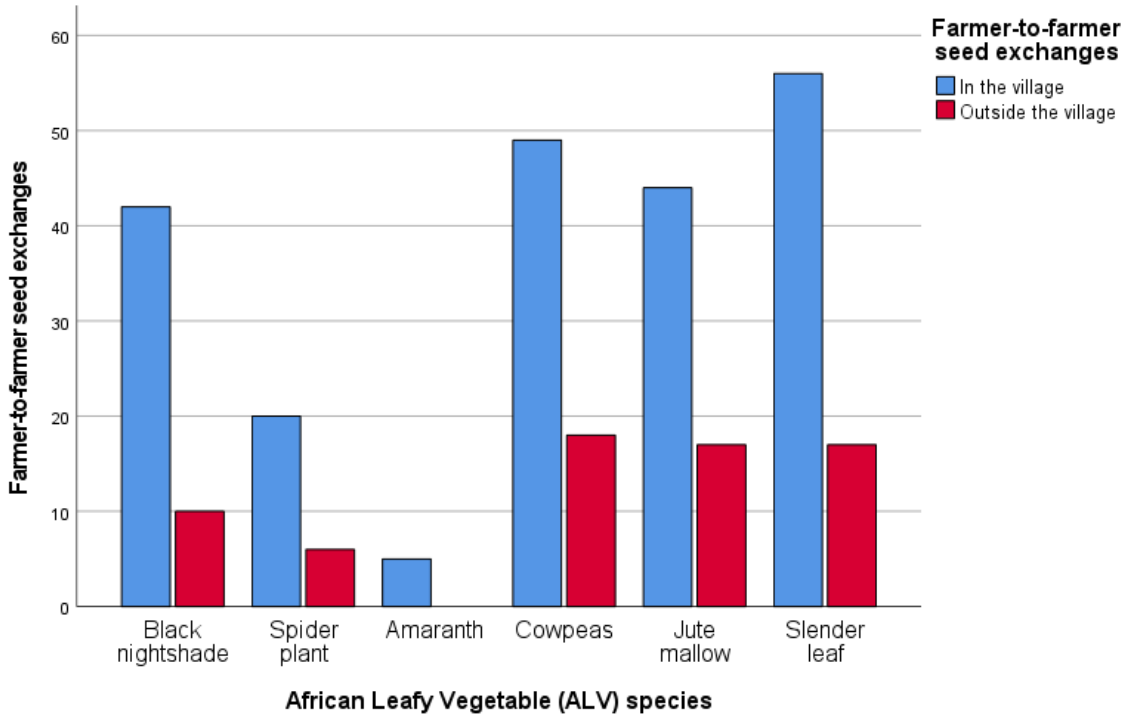

Figure 5: Number of farmer-to-farmer African Leafy Vegetable (ALV) seed exchanges for select species in and outside the village (n=431).

5.2.3. Factors affecting the informal ALV seed system

Where farmers source their ALV seeds is significantly influenced by two factors: whether or not they have an income from the sale of ALVs and the total number of ALV species they cultivate. A chi-square test showed a strong strength of association between the source of ALV seeds and income from ALVs (X^2=13.933, p<0.01, Cramer's V=0.168). This significance stems predominantly from the production of own seeds. Whether or not farmers have an income from ALVs significantly influences how likely they are to produce their own seeds. In other words, if farmers have an income from the sale of ALVs, they are significantly more likely to use their own seeds. In addition to income from ALVs, the total number of ALV species which are cultivated by farmers also significantly influences their source of seeds (X^2=32.169, p<0.05, Cramer's V=0.256). This very strong association stems predominantly from the group of farmers who cultivate four or more species of TLVs. They are more likely to use their own seeds when cultivating ALVs and less likely to use the local market.

The diversity of different seed sources used per household is influenced by the total number of ALV species cultivated (B: 0.139, p<0.01). The diversity of seed sources used increases with the diversity of ALV species cultivated. All other factors (market access, household income, household and women demographics, and income from the sale of ALV products) were not proven to significantly influence the diversity of seed sources used by households.

The number of farmer-to-farmer exchanges a household uses to supply or obtain ALV seeds is influenced by three factors: the location of the household, the number of off-farm sources of income, and the number of ALV species cultivated. The negative binominal regression shows a positive relation between three sublocations and the number of farmer-to-farmer ALV seed exchanges. Farmers living in Bugina (B: 1.299, p<0.01), Ebunangwe (B: 1.368, p<0.01) and Ebuhando (B: 1.028, p<0.05) have significantly higher rates of exchanges than farmers in the other 13 sublocations. Farmer-to-farmer exchanges have a negative relationship to the number of off-farm sources of income (B: -0.359,

p<0.01). This means that when farmers increase their off-farm sources of income, the number of exchanges between farmers decreases. A positive relationship was found between the number of exchanges and the number of ALVs species cultivated (B: 0.276, p<0.001), as was the case with the diversity of seed sources.

Finally, no significant association was found between the relationship of farmers in farmer-to-farmer seed exchanges. Market access, household income, household and women demographics and the cultivation of ALVs were not shown to affect the relationship between farmers.

5.3. Women participation and decision making

5.3.1. Women participation and decision making in the cultivation of ALVs

The participation and decision making of women in ALV cultivation is high. Over three/fourths of women make the decision for the household whether to cultivate ALVs and are responsible for ALV cultivation (**Error! Reference source not found.**). When selling ALVs, the percentage of women able to decide whether to sell ALVs falls slightly to 65.5%, while falling even more to 57.7% when deciding how the money is used. Nonetheless, the trend is that women are more involved in ALV production and sales than men.

When it comes to selling ALVs, men in the household gain in importance, becoming either the sole decision maker or in combination with the woman. Only slightly over 10% of men decide whether to cultivate ALVs, and even less are responsible for the cultivation. This changes with the sale of ALVs, where over one/fourth of households report that both the man and the woman decide how the money is spent. Other family members are rarely involved in the decision making of ALV cultivation, however in over 8% of households various family members are responsible for ALV cultivation.

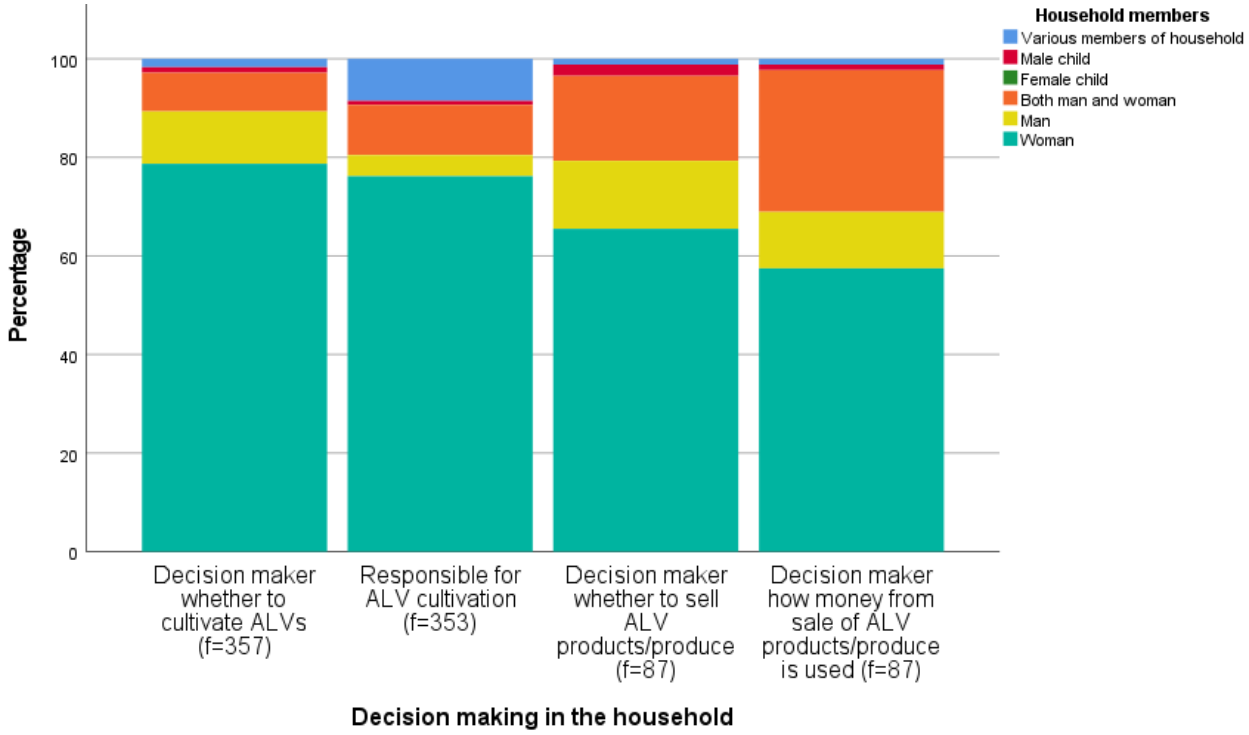

Figure 6: Household decision making by household members regarding African Leafy Vegetable (ALV) cultivation. Results are in percentage (n=431, respective f per kind of decision making is 100%).

The final decision made in the household which ALVs species are cultivated is made predominantly by the woman herself (71.6%). Only 15.5% of the men make the final decision and in the rest of the households, other members are involved. In those cases where women do not make the final decision, almost 50% of women reported that they feel to a high extent that they can make their own personal decision regarding which ALV species are cultivated. Additionally, few women felt that they did not have any say regarding which ALV species are cultivated.

There is a significant and strong relationship between who is responsible for ALV cultivation and the total number of ALV species cultivated (X^2= 35.346, p<0.1, Cramer's V= 0.316). When men alone are responsible for ALV cultivation, they are significantly more likely not to cultivate any ALV species. This means not only are women in this case to a higher degree responsible for ALVs, but they are also more likely to cultivate (multiple) ALVs.

When women are responsible for the cultivation of ALVs, they are significantly more likely to be able to decide whether to sell ALV produce and products (X^2= 141.948, p<0.001, Cramer's V= 0.639). 81.3% of women who are responsible for cultivation decide whether to sell ALVs. At the same time, when women make the decision to sell ALVs, they are significantly more likely to be able to decide how this money is used, either alone or with their spouse (X^2= 161.145, p<0.001, Cramer's V= 0.699). When women make the decisions to sell ALVs, 80% of them also make the decision how to use the money from the sale. When both men and women make the decision whether to sell ALV products, they are most likely to decide together what to do with the money (78.6%).

5.3.2. Women participation and decision making in the informal ALV seed sector

In general, the extent of participation and decision making by women was not found to have a significant influence on the informal seed system. The only variable which is affected by the participation and decision making of women is the diversity of different seed sources used per household (X^2= 29.134, p<0.01, Cramer's V= 0.167). When men are responsible for the cultivation of ALVs, they are more likely not to source any seeds. This plays into the finding that one, men are often not responsible for the cultivation of TLVs, and two, if they are, they are more likely not to cultivate ALVs. For this reasoning, it was difficult to find significant findings in the relationship between participation and decision making in the informal seed sector since there were too few men involved in cultivation.

6. Discussion

6.1. ALV cultivation

African Leafy Vegetables (ALVs) continue to be a vital crop for smallholder farmers in Western Kenya, with most farmers growing one or more species of ALVs (Gotor and Irungu 2010, Mwaura et al. 2013, Pincus et al. 2018). The results of my study confirm the importance of ALVs, as over 88% of the 431 smallholder farmers surveyed in Vihiga County cultivate ALVs. They grow a wide range of species, including (in order of frequency of cultivation): cowpea leaves, slender leaf, jute mallow, Ethiopian kale, black nightshade, pumpkin leaves, spider plant, amaranth, cassava leaves, and finally vine spinach (Table 4 for binomial nomenclature and local names). The agrobiodiversity found on smallholder farms is an integral part of localized culture and sustainable livelihoods, with the potential to increase nutritional security and food sovereignty (Abukutsa-Onyango 2007, Towns and Shackleton 2018). However, even though ALVs contribute substantially to food security and are a part of livelihood strategies for smallholder farmers, they remain a neglected species, seldom integrated in development plans and policies and rarely researched (Chelang'a et al. 2013, Chweya and Eyzaguirre 1999).

While the increase in cultivation of ALVs in Kenya is attributed primarily to consumer demand, particularly from peri-urban and urban consumers (Chelang'a et al. 2013, Mwaura et al. 2013),

smallholder farmers in Vihiga County do not primarily grow ALVs for income, but rather for food security. While ranking the contribution of the different ALV species for food security and income from one to five, all ALVs were ranked higher individually and collectively for food security than for income. The highest ranking ALV for household income, which is amaranth at an average mean of 1.62, is quite low. The minimal importance of ALV cultivation and sale for household income could be attributed to the fact that so few households sell their produce. Only 25.7 % of the households (n=431) sold their ALV products or produce in the 12 months preceding the survey. The access to markets was also not proven to significantly influence whether households cultivate ALVs (r_s: 0.04, $p>0.5$). This contrasts with results from the Kiambu District near Nairobi, where those households closer to the market were significantly more likely to cultivate ALVs than those farther off (Mwaura et al. 2013).

However, even though ALVs are ranked lower in terms of importance for household income and only one/fourth of the smallholder farmers sell their products or produce, the sale of ALVs and other vegetables is still the most frequent source of income stemming from on-farm production. This underlines the difficulties smallholder farmers face in acquiring streams of income, as over half of the households do not have any sources of income stemming from on-farm production. While off-farm sources of income are more frequent than on-farm sources of income, off-farm income is in 80% of the households lower than on-farm income. In conclusion, the sale of ALVs is still of importance to the income of households, but is embedded in the broader situation of smallholder farmers unable to sell their produce, contributing to the fact that 41% of households in Vihiga County live under the poverty level (Kenya National Bureau of Statistics 2019).

Household income is significantly associated with the cultivation of ALVs, although the reasons for this association require further research. The number of different on-farm sources of income is weakly positively correlated (r_s: 0.225, $p<0.001$) with the number of ALV species cultivated. Households in Vihiga County that primarily depend on income from the farm may be more likely to cultivate multiple ALVs, increasing the agrobiodiversity on their farm, as seen in the Kiambu District near Nairobi (Mwaura et al. 2013). Additionally, larger smallholder farms may be more able to cultivate diverse species of ALVs. These hythosesis could also be supported by the significant, although very weak, negative correlation (r_s: -0.143, $p<0.01$) between off-farm sources of income and the number of ALV species cultivated. It may be that the less of an importance the income stemming from the farm is for household income, (which could be related to the size of the farm) the less smallholders farmers cultivate ALVs. However, land size was not shown to significantly influence farmer's decision to cultivate ALVs in the Kiambu District (Mwaura et al. 2013).

6.2. Importance of women in cultivating ALVs

Women are central actors in the cultivation of ALVs on smallholder farms in Kenya. Over three/fourths (n=431) of the women in Vihiga county are not only responsible for ALV cultivation, but also make the decision whether to even cultivate ALVs. Furthermore, women are significantly more likely to cultivate ALVs than men, with men more likely to not cultivate any ALV species ($X=35.346$, $p<0.1$, Cramers $V=0.316$). These results underline how labor on smallholder farms and in the household are often divided by gender (Delêtre et al. 2011, Schöley and Padmanabhan 2017) and also underline the importance of women for the cultivation of ALVs. The "gender-asymmetric person-plant relationship" (Delêtre et al. 2011) applies to women and ALVs, as they gain expertise and assert authority with the cultivation. Not only are men less likely to cultivate ALVs, they also consult the female members of the household for information regarding planting and production methods, as they lack expertise (Nekesa and Meso 2018, Pincus et al. 2018). Over 70% of women feel they have full authority regarding which ALVs species are cultivated and very few women feel that they do not have any say regarding species selection. Additionally, with an increase in age, women are more likely to cultivate multiple ALV species (r_s: 0.32, $p<0.01$).

While women are responsible for the cultivation of ALVs in Kenya, their perspectives, knowledge and experience have historically been excluded from agricultural research and development (Chambers and Momsen 2007, Ferguson 1994). This exclusion stems in part from the neoclassical model of the household as a unitary entity, focusing on the male head of the household and thereby ignoring the gendered social organization of labor and power (Schöley and Padmanabhan 2017). A gendered perspective on agriculture highlights gender asymmetry and intrahousehold dynamics, especially intrahousehold power dynamics, which dictate who has control over what (Doss 2013, Dolan 2001, Nkengla-Asi et al. 2020, Orr et al. 2016, Quisumbing, Agnes R. ed. 2003, Wencélius et al. 2016). Women in Vihiga County have a high operational control over ALV cultivation, as they decide which ALV species are chosen and how the resources are managed.

When looking at the financial control in terms of deciding how the income of the sale of ALVs is used, the participation and decision making of women drops slightly but remains primarily in the control of women, with 57.7% of women in Vihiga County deciding how the money from the sale of ALVs is used. When women are responsible for the cultivation of ALVs, they are significantly more likely to be able to decide whether to sell ALV produce and products (X^2=141.948, p<0.001, Cramer's V=0.639). Furthermore, when women make the decision to sell ALVs, they are significantly more likely to decide how the money is used (X^2=161.145, p<0.001, Cramer's V=0.699). This is key to understand women's decision-making ability and is essential for gender equality (Nkengla-Asi et al. 2020). Women-controlled resources, in this case the sale of ALVs, not only increases their bargaining power in the household, but also improves the situation of women and children's health, nutrition, and education (Quisumbing 2003a). As mentioned by Nekesa and Meso (2018): "For anyone interested in rural women's welfare, African traditional vegetables offer an important entry point."

ALVs can be an entry point but not the end point to women's welfare in Western Kenya. The patriarchal sociocultural and political system can hinder interventions geared towards gender equality through ALV cultivation (Ferguson 1994). First, even though women dominate the Kenyan ALV supply chain, men who are involved earn significantly higher incomes than women (Weinberger et al. 2011). This means that while supporting women in the cultivation and sale of ALVs can increase women-controlled resources, women still face discrimination every step of the way. Second, the operational and financial control of women over ALV cultivation is more likely when ALVs are first and foremost cultivated for subsistence, as is the case in Vihiga County. With the commodification, commercialization and subsequent increase in income from ALV production, gendered intrahousehold dynamics can shift, with men more inclined to participate and appropriate the work and benefits derived from ALVs (Weinberger et al. 2011). This has proven to be the case with multiple crops in Kenya (Abukutsa-Onyango 2005, Dolan 2001, Fischer and Qaim 2012). Therefore, supporting ALV cultivation does not automatically lead to an increase women's welfare, income, or emancipation.

Developmental policies and programs which aim at improving the situation of women and children through the cultivation of ALVs need to be aware of gendered intrahousehold power dynamics and include strategies to increase the resources controlled by women. Commercialization can be an opportunity for cooperation and transformation in the household. However, this depends on the specific historical and cultural context of women's bargaining power and the kind of intervention (Orr et al. 2016). "While taking existing gender norms into account is important, adapting to existing norms runs the risk of reinforcing them, rather than using the project as an opportunity to be gender-transformative or to engage men to support the project." (Quisumbing et al. 2015)

6.3. ALV seed system

The ALV seed system in Western Kenya is dominated by informal seed sources (Abukutsa-Onyango 2005, Nekesa and Meso 2018, Pincus et al. 2018). Over 90% of the seeds sourced by smallholder farmers in Vihiga County stem from three informal seed sources: the local market, own seeds, and

neighbors, fellow farmers, or family members (i.e. farmer-to-farmer exchanges). This is consistent with patterns in the Global South, where smallholder farmers source likewise over 90% of their seeds from the informal seed system (McGuire and Sperling 2016). ALV seeds from informal seed sources are in general more easily accessible, are less expensive and can have higher germination rates and yields than seeds from the formal seed system (Croft et al. 2018, Pincus et al. 2018) Additionally, informal seed sources are often the only source for local varieties and neglected and underutilized crops (Gill et al. 2013*,* Schöley and Padmanabhan 2017), such as the ALV species cultivated in Vihiga County.

While in the last 20 years, the number of seed sources utilized by smallholder farmers has increased (Schöley and Padmanabhan 2017), the diversity of ALV seed sources utilized by farmers in Vihiga County is quite limited. Most households (62.2%) only source their ALV seeds from one of eight seed sources (own seed, neighbors/fellow farmers/family members, local market, extension services, seed companies or traders, farmer groups, NGOs, and other sources). The lack of diverse seed sources is embedded in the challenges farmers face in the Global South with accessing seeds (McGuire and Sperling 2011, Stromberg et al. 2010). The reliance on only one source heightens seed insecurity (Louwaars and Boef 2012), which is already strained through the high demand and low supply of ALVs seeds in the formal and informal market (Pincus et al. 2018).

The local market is by far the main source of seeds in the larger context of Africa (McGuire and Sperling 2016), as well as in the specific context of ALV seeds in Vihiga County. However, this is in contrast to other studies in Western Kenya, which concluded that self-produced ALV seeds are the most frequent source (Abukutsa-Onyango 2005, Nekesa and Meso 2018, Pincus et al. 2018). This illustrates how the availability of seeds differs widely between counties (Pincus et al. 2018). Over 85% of households in Vihiga County mentioned the local market as their main source of ALV seeds, irrespective of ALV species, with the exeption of amaranth. Reasons for sourcing seeds from the local market can include accessing new varities for experimentation, replenishing depleted on-farm seed stocks and outsourcing seed production and storage (Sperling and McGuire 2010). Additionaly, social networks key for farmer-to-farmer exchanges appear to be erroding, leading farmers to seek out local markets. However, further research is required to understand why farmers utilize which ALV seed sources in Western Kenya.

The source of ALV seeds utilized by smallholder farmers in Vihiga County is significantly and strongly dependent on the indiviual ALV species ($X=251.422$, $p<0.001$, Cramer's $V>0.5$). Except for amaranth, all ALV seeds are predominantly sourced from the local market. Amaranth is significantly more likely to be sourced from on-farm seed production, with 36.1% of households sourcing from on-farm production. The reliance on on-farm seed production for amaranth may be explained by the easy collectability of amaranth seeds, the high germination rate (Croft et al. 2018), and by seed dispersal characteristics, where seeds fall naturally to the soil and germinate the following year. Contrarily, black nightshade seeds are significantly more likely to be sourced from extension services than other ALV species. The shift to the formal system for black nightshade seeds may be explained by the labor and time intensive collection and preparation of black nightshade berries (Schippers 2000) and/or by the willingness of farmers to invest in perceived higher quality seeds, as fresh nightshade leaves are more marketable than other ALVs (Pincus et al. 2018).

Farmer-to-farmer seed exchanges

Even though social systems and networks underlying farmer exchanges appear to be eroding (Sperling and McGuire 2010) and the Kenyan National Seed Policy bans farmer seed exchanges and informal purchases (Mucioki et al. 2018), over one/third of smallholder farmers in Vihiga county have

exchanged ALV seeds with one or more farmers in the last year. These farmer seed systems continue to be an important source of seeds and are vital for in-situ conservation, increasing seed diversity and building the basis for crop improvement around the world (Badstue et al. 2006, Coomes et al. 2015, Stromberg et al. 2010). However, it is difficult to estimate precise seed flows, as smallholder famers in the Global South rarely keep records of their seed transaction and researchers are dependent on the recalled accounts given (Badstue et al. 2006). Nonetheless, one/third of farmers recalled suppling ALV seeds to other farmers in their village in the past year, the most frequent type of exchange mentioned. These seeds could be supplied through sale, inheritance, gift, barter, lending or through another type of exchange (Badstue et al. 2006, McGuire and Sperling 2016). Unfortunalty, data on the type of seed transaction was not collected and further research is necesarry to identify how farmers access their seeds. This can be informative when looking at seed vulnerability, community solidarity (Tadesse et al. 2017), and the willingness of farmers to invest in seeds (McGuire and Sperling 2016).

The relationship between farmers is key in farmer seed exchanges, with farmers obtaining and supplying their seeds from trustful sources, predominately from relatives (Delêtre et al. 2011, Kiptot et al. 2006, Tadesse et al. 2017) or custodian farmers (Sthapit 2013). The reliance on relatives was evidently the case in Vihiga County, where over 70% of seed exchanges are done between farmers who are related to one another, either by birth or blood, by marriage or by tribe. Exchanging seeds through close social relationships can minimize transaction costs due to social ties and responsibilities and oftentimes are done ad hoc, as part of an ordinary social interaction (Badstue et al. 2006). Social relationships are especially relevant for seed exchanges outside the village, where farmers in Vihiga County are significantly more likely to exchange seeds with relatives. Additionally, the varieties have likely been cultivated and bred in the same community under similar conditions and farmers can share experiences and knowledge regarding cultivation (Badstue et al. 2006). However, a chi-square test did not show that ALV species influence whether farmer-to-farmer seed exchanges are inside or outside the village. Therefore, the relationship of farmers in farmer-to-farmer seed exchanges determines whether seeds are exchanged in or outside the village, not the ALV species.

Factors influencing the informal ALV seed system

In Vihiga County, the diversity of ALV species cultivated (agrobiodiversity) was found to be the defining factor influencing the informal ALV seed system. Farmers cultivating multiple ALV species are more likely to produce their own seeds, less likely to source their seeds from the local market, have in general a higher diversity of seed sources and exchange seeds with more farmers. Farmers cultivating multiple ALV species are vital for agrobiodiversity and in-situ conservation of ALVs, especially in times of climate change, land use intensification, urbanization and structural change in the rural population (Badstue et al. 2006, Coomes et al. 2015, Pautasso et al. 2013, Stromberg et al. 2010). Additionally, they are not only more seed secure, able to control their own access to seeds and utilize multiple sources in times of crisis (Pincus et al. 2018), but they also have and are able to share their knowledge and experience regarding ALV cultivation and the traits of their seeds. Farmers cultivating many different ALV species thereby act as central custodians in farmer seed networks, actively selecting, maintaining and disseminating agricultural biodiversity through seeds and knowledge (Badstue et al. 2006, Sthapit 2013).

Women are key actors in the informal seed system, crucial for agrobiodiversity (Almekinders and Louwaars 2002, Bezner Kerr 2013, Delêtre et al. 2011, Gill et al. 2013, Mucioki et al. 2016, Nkengla-Asi et al. 2020, Violon et al. 2016). Not only are women more likely to cultivate ALVs, but they are also more likely to source ALV seeds and have a higher diversity of different seed sources than men ($x=29.134$, $p<0.01$). As women are more likely to cultivate multiple ALV species, and this agrobiodiversity indicates the centrality of farmers in the farmer seed network, women are thereby central custodians in the ALV seed system in Vihiga County. Seeds and knowledge are exchanged

and passed through generations of women, as the seed systems in Kenya are matrilineal (Mucioki et al. 2016). Women are essential for seed production, selection, conservation, and storage and are the holders of agro-ecological knowledge on seeds and varieties (Nkengla-Asi et al. 2020). While women in general are central custodians in the ALV seed system, the extent of participation and decision making by women in the cultivation of ALVs was not found to significantly influence any other aspects of the informal seed system (such as seed source selection, the number of farmer-to-farmer seed exchanges or the relation between farmers in farmer seed exchanges).

In addition to agrobiodiversity, households that have an income from the sale of ALVs are also significantly more likely to use their own seeds for cultivation ($X=13.933$, $p<0.01$, Cramer's $V=0.168$). These results contrast with former studies, where increases in income from on-farm production and the proximity of markets have led farmers to purchase seeds, instead of using land and labor-intensive seeds produced on their farm (Cavataasi et al. 2006, Croft et al. 2018, Stromberg et al. 2010). However, both on-farm sources of income and market access were not found to significantly influence the informal ALV seed system in Vihiga County. This aligns with the present lack of influence that market access has on the cultivation of ALVs in Vihiga County. It may be that households with an income from the sale of ALVs cultivate a larger area of land, and thereby have more means to produce their own seeds (McGuire and Sperling 2016). Another factor could be the general lack of available and accessible quality ALV seeds in Kenya (Croft et al. 2018, Pincus et al. 2018), leading farmers to rely heavily on their own seeds.

With the exception of location and gender, household demographics were not shown to influence the informal seed system. Education level and age has previously been shown to not influence seed sourcing in Kenya (Croft et al. 2018), although in other contexts, an association between age and source selection has been detected (Wencélius et al. 2016). Regarding location, three sublocations in Vihiga County showed higher rates of farmer-to-farmer exchanges. Further research and analysis are necessary to understand what factors attribute to these higher rates of farmer-to-farmer exchanges. In addition, many factors were not included in this study, such as quality of seeds, accessibility, type of exchange, etc. Further explorative research is also necessary to understand the informal seed system, as this research field is underfunded, underdeveloped and little is known about even the informal seed systems of major crops such as maize (Gill et al. 2013).

7. Conclusion and Outlook

African Leafy Vegetables (ALVs) continue to be a vital crop for smallholder farmers in Wester Kenya, with the potential to improve food sovereignty and nutritional security. Over 88% of smallholder farmers in Vihiga County cultivate up to ten different ALV species. However, ALVs are a neglected species, seldom integrated in national and international development plans and rarely researched (Chelang'a et al. 2013, Chweya and Eyzaguirre 1999). My study, which uses baseline data from 431 households in Vihiga County, Kenya, highlights the continued prevalence of ALV cultivation, especially in the hands of women, and the importance of ALVs for food security. While ALV cultivation on smallholder farms has many agronomic advantages compared to the cultivation of "exotic" vegetables, smallholder farmers still face many challenges, with the main constraint being the lack of available and accessible quality seeds.

My study shows that the ALV seed system in Western Kenya is dominated by informal seed sources, with over 90% of seeds sourced in Vihiga County stemming from three sources: the local market, own seeds, and farmer-to-farmer exchanges. Farmers cultivating many different ALV species in Vihiga County act as central custodians in the informal seed system, actively selecting, maintaining and disseminating agricultural biodiversity through seeds and knowledge (Badstue et al. 2006, Sthapit 2013). The informal seed system, a key pillar of farmer livelihoods and small-scale agriculture, is vital for in-situ conservation, maintaining and increasing agrobiodiversity and ensuring future crop

improvement around the world (Badstue et al. 2006, Coomes et al. 2015, Stromberg et al. 2010). However, dominant agricultural development regimes promote large-scale policies and initiatives by agribusinesses (Coomes et al. 2015) and research on informal seed systems, while growing, is still underdeveloped and underfunded (Gill et al. 2013).

Women are key actors in the cultivation of ALVs on smallholder farms in Vihiga County and in the informal ALV seed system (Almekinders and Louwaars 2002, Delêtre et al. 2011, Gill et al. 2013, Mucioki et al. 2016, Nkengla-Asi et al. 2020, Violon et al. 2016). My results show that women are more likely to cultivate ALVs, are more responsible for ALV cultivation than men and make most of the decisions regarding cultivation, sale and income through ALVs. Not only are women more likely to cultivate ALVs, but women are also the central custodians in the ALV seed system in Vihiga County. Future developmental policies and programs which aim at increasing ALV cultivation and consumption are strongly urged to not only include women but put women at the forefront of their programs. Additionally, developmental policies and programs, as well as research projects, which aim at improving the situation of women and children through the cultivation of ALVs need to be aware of gendered intrahousehold power dynamics and include strategies to increase the resources controlled by women. While ALV cultivation, sale and income through ALVs at present remain in the hands of women, the commodification, commercialization and subsequent increase in income from ALV production can lead gendered intrahousehold dynamics to shift, with men more inclined to participate and appropriate the work and benefits derived from ALVs (Weinberger et al. 2011). Supporting ALV cultivation does not automatically lead to an increase in women's and children's welfare, income, or emancipation. Understanding gendered intrahousehold dynamics and the gendered informal seed system of ALVs is essential for supporting ALV cultivation, ALV community seed bank initiatives and on-farm ALV seed conservation projects.

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11. Appendix

11.1. Tables

Table 4: Binomial nomenclature, English name, and Luhya, Luo and Kiswahili names of common African Leafy Vegetables

Binomial nomenclature	**English name**	**Luhya**	**Luo**	**Kiswahili**
Solanum villosum/S. scabrum	Black nightshade	(Li)suza/msucha/risutsa/lisutsa	osuga	managu/mnavu

Crotolaria brevidens/C. ochroleuca	Slender leaf (sun hemp)	emiro	mitoo/miro o	marejea
Cleome gynandra	Spider plant	saga/tsisaka	dek	mgagani
Corchorus olitorius	Jute mallow	Mtere/(o)murere	apot(h)	m(u)renda/mlen da
Vigna unguiculata	Cowpea leaves	(alot)-boo/Likhubi	likovi	kunde
Amaranthus spp.	Amaranth	Zimboga (tsimboka/tsimboga)/Libokoi	(o)dodo	M(u)chicha/terer e
Cucurbit spp.	Pumpkin leaves	(li)seveve/lisabebe	(it)budho	(Matawi ya) malenge
Brassica carinata	Ethiopian kale	Kanzira/Kanjira	Kandhira	sukuma
Basella alba	Vine/malaba spinach	(i)nderema/indelema		
Manihot esculenta	Cassava leaves	Amatsafu ki miogo		miogo

Source: (Abukutsa-Onyango 2007, Schippers 2000)

Table 5: Selected topics of social demographics of households: relationship to household head, marital status, marriage relationship and level of education (n=431).

Social demographics		percentage
Relationship to household head	Household head	12.53%
	Spouse/wife	66.82%
	Daughter	14.62%
	Grandchild	1.80%
	Relative	2.09%
	Parent	0.46%
	Other	1.62%
Marital status	Married	81.67%
	Separated	3.71%
	Widowed	2.55%
	Single	12.06%
	Divorced	0.00%
Marriage relationship	Monogamous	96.98%
	Polygamous	3.02%
	Other	0.00%

Level of education	Lower primary	2.33%
	Upper primary	54.65%
	High school	33.26%
	College/University	5.12%
	Other	4.65%

Table 6: On-farm and off-farm sources of income household income (n=431).

On-farm and off-farm sources of income household income	yes (frequency)	percentage
On farm source of income by sale of own produced grains	41	9.5%
On farm source of income by sale of own produced roots or tubers	32	7.4%
On farm source of income by sale of own produced fruits	31	7.2%
On farm source of income by sale of own produced TLVs	95	22.0%
On farm source of income by sale of own produced other vegetables (non-TLVs)	100	23.2%
On farm source of income by sale of own produced animals or animal products	80	18.6%
Off farm source of income as petty trader	70	16.2%
Off farm source of income by sale of own produced or gathered goods/crafts	13	3.0%
Off farm source of income as mechanic (motorcycle/bicycle repair)	20	4.6%
Off farm source of income as casual laborer (daily wages)	142	32.9%
Off farm source of income as hairdresser	20	4.6%
Off farm source of income as boda-boda driver	22	5.1%
Off farm source of income as metal worker or carpenter	9	2.1%
Off farm source of income from remittances	7	1.6%
Off farm source of income as employee (regular salary)	46	10.7%
Off farm source of income from cash transfer programs	5	1.2%
Off farm source of income - non-specified	23	5.3%
Higher earnings as petty trader compared to farming	15	3.5%
Higher earnings by sale of own produced or gathered goods/crafts compared to farming	9	2.1%
Higher earnings as mechanic (motorcycle/bicycle repair) compared to farming	5	1.2%
Higher earnings as casual laborer (daily wages) compared to farming	34	7.9%
Higher earnings as hairdresser compared to farming	6	1.4%
Higher earnings as boda-boda driver compared to farming	4	0.9%
Higher earnings as metal worker or carpenter compared to farming	4	0.9%
Higher earnings as employee (regular salary) compared to farming	17	3.9%
Higher earnings from remittances compared to farming	3	0.7%
Higher income from cash transfer programs compared to farming	0	0.0%
Higher income from non-specified off farm source compared to farming	4	0.9%

Table 7: Ownership of household assets (n=431).

Household asset	percentage
Hoe	91.2%
Radio	74.7%
Mobile (not smartphone)	72.4%
Sofa set	52.9%
Spade/shovel	40.4%
Solar panel	34.8%
Kersone stove	32.0%
Television	28.5%
Smartphone	28.1%
Improved modern jiko	21.6%
Wheelbarrow	20.6%
DVD player	19.7%
Bicycle	15.1%
Motorcycle	13.0%
Cooker/gas stove	8.8%
Sprayer pump	7.0%
Car battery	6.0%
Sewing machine	5.1%
Refrigerator	2.3%
Water pump	2.1%
Generator	1.9%
Plough	1.6%
Computer	1.2%
Car/truck	0.9%

Table 8: Summary of sources of income and household assets (n=431).

	Mean	Minimum	Maximum
Number of sources of on-farm income	0.96	0	6
Number of off-farm sources of income	0.90	0	3
Number of off-farm sources of income with higher income compared to farming	0.23	0	3
Total number of household assets	5.82	0	16

11.2. Questionnaire

11.2.1. Demographic and Socio-Economic Characteristics

Identification Table

Sub-location		Village		Date	……./11/2018
Interviewer ID:		Respondent name		Sex [1=M, 0=F]	
Household profile		1=Monogamous 2= Polygamous 99= Other, specify			
Household religious affiliation		1=Christianity 2 = Islam 99 = Other, specify			

QUESTION 1: DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS

A: Household Profile

S/No	1.1 Name (first name only)	1.2 Relationship to HH head 1=HHH 2=spouse/ wife 3=son 4=daughter 5=grandchild 6=relative 7=parent 8 = domestic worker 9= Others, specify	1.3 Sex 1= M 0 = F	1.4 Age[2] (years /months)	1.5 Marital status *-codes-* 1=married 2=separated 3=widowed 4=single 5=divorced 97=not applicable[3]	1.6 Level of Education *-No of year/codes-* 97=Not applicable[4] 98=college/university 99=others (specify)	1.7 Main Occupation 1=salaried employee[5] 2=farmer 3=self-employment/business 4=casual labourer 5=student 6=housewife 7 = unemployed[6] 8 =Others,specify 9= n/a[7]	1.8 Contribution to HH 1= nothing 2= money 3=labour 4=childcare 5=Less than 15yrs 6= savings 7= pension

B: Household income

1.9	What are the sources of income for your household throughout the year? [***List as many as relevant to the household***]	0= no, 1= yes
	On farm sources of income	
	Sale of own produced crops grains eg maize, sorghum, millet, amaranth	
	Sale of own produced crops legumes/pulses eg beans, peas, green grams, cowpeas, ground nuts	
	Sale of own produced roots or tubers eg cassava, arrow roots, potatoes	
	Sale of own produced fruits eg mangoes, papayas, guavas, jackfruit	
	Sale of own produced TLVs[8]	
	Sale of own produced non-TLVs[other vegetables] eg kales, spinach, pumpkins, cabbage etc	
	Sale of own animal or produced animal products eg eggs, milk	

[2] Indicate months for children under 5 years

[3] Ask only for those over 15 years and who are not in school

[4] For children less than 6 years old

[5] For both adults and for children above 10 years who are employed

[6] Anyone 18 years and above and not in school, college or employed

[7] For children less than 15 years and elderly people older than 65 years

[8] 1=Black nightshade (Lisutsa); 2 = Spider plant (Saga); 3 =Amaranth (Tsimboka), 4=Cowpeas (Kunde); 5 = Jute mallow (Murenda); 6 = Clotolaria (Mito)

1.20	**Off-farm sources of income**	0= no, 1= yes	1.21 Do you earn more from [ACTIVITY] more compared to your farming activity? 0= no, 1= yes
	Petty trader		
	Sale of own produced or gathered goods/crafts (charcoal, stones, firewood, baskets, etc…)		
	Mechanic/motorcycle or bicycle repair		
	Casual labour/temporary salary (daily wages)		
	Hair salon		
	Boda boda		
	Metal fabrication and carpentry		
	Employment/ regular salary		
	Remittances		
	Cash transfer program eg pesa ya wazee		
	Other, Specify		

C: Market access

	1.22 Which is the nearest market that you frequent for:	1.23 Name of market	1.24 Time to the market **when walking**	1.25 Frequency of visit	
				Visits	Every: 1=day,2=week; 3=month; 4=year; 99=Other, specify
	Purchase food items from?				
	Sell your produce				

C: Housing

1.26	*Where possible interviewer to directly observe and respond.*	
	What is the floor of your main residence made of? *(1=Earth floor; 2=stone; 3=cement;4= tile; 5=wood; 99= other (specify)) (1ANSWER)*	
	What are the walls of your main residence made of? *(1=Wood; 2=earth wall; 3=iron sheet; 4=stone; 5=brick; 6=cement; 99=others (specify) (1ANSWER)*	
	What is the roof of your main residence made of? *(1=Straw/grass; 2=iron sheet; 3=tile; 4=cement; 5=bamboo; 99=others (specify)) (1ANSWER)*	
	What kind of toilet facility does your household use? *(1=No facility/bush/field, 2=open pit/traditional pit latrine, 3=improved pit latrine (VIP), 4=pour flush latrine, 5=flush toilet, 99=other (specify))*	
	Is your toilet facility located within your dwelling, or yard or compound? *(1=Yes, 2=No) (1ANSWER)*	
	Is there electricity in the house? *(1=Yes, 2=No) (1ANSWER)*	
	What type of fuel does your household mainly use for cooking? *(1=Electricity, 2=LPG/Natural gas, 3=Biogas, 4=kerosene, 5=coal/lignite, 6= charcoal, 7=firewood/straw, 8=dung, 99=other (specify))*	

D: Household Assets

1.27 *Ask the respondent* **"**Do you own a [asset name]?" *Record 1=Yes, 0=No.*

Asset name		**Asset name**	
Cooker/gas stove		Improved modern jiko	
Refrigerator		Car/truck	
Radio		Motorcycle	
Television		Bicycle	
DVD player		Hoe	
Smart phone		Spade/shovel	
Other mobile type		Plough	
Sewing machine		Sprayer pump	
Computer		Water pump	
Generator		Wheelbarrow	

	Solar panel			Kerosene stove	
	Car battery			Sofa set	

11.2.2. Household Agricultural Practices and Farm Diversity

QUESTION 4: HOUSEHOLD AGRICULTURAL PRACTICES AND FARM DIVERSITY

Now I would like to ask you some questions about the land you use for farming and other activities, as well as the crops that you grow on your farm. These questions collect important information about your particular situation and form a baseline understanding for the rest of the survey.

[Help the farmer to describe all the farms/land they have access to for purposes of farming grazing and residence then sketch the farms/plots and name them with codes eg F1, F2, for farms; P1, P2 for plots, HG1, HG2 for kitchen gardens and W1, W2 for woodlots]

We would like to know during the last year how much land you owned, rented or shared for the following activities (in acres). Probe for all lands						
A: Land Ownership						
4.1 Land code assigned by enumerator	4.2 Land use type 1=Cultivation of crops 2=Grazing 3=Bush/forest 4=Residence 5=Kitchen garden 6=Fallow 99=Other, specify	4.3 Who owns this land? 1=Own 2=Rented 3=Share (jointly own or jointly rented) 4=Community owned 5=Government land 6=Don't know owner 99=Other, specify	4.4 Size of the land [approximate in acres] (conversion: $1m^2$=0.000247105 acres)	4.5 What were the three major crops grown on [LAND] during the <u>last growing season</u>? *[List up to three with primary crop first]*		
4.6 Do you or your household have any land that you have leased out?			[1=yes; 0=no]		4.7 Size in Acres	

B: Crop diversity

This study is designed to learn about your use and adoption of new farming technologies and practices. First, we would like to know more about the crops you grow and the changes you have made to the crop varieties you have planted over the last two seasons. You have already told me about some of the crops that you grow in your farm. Are there any other crops that you grow that you have not listed (above)? Probe.

4.8 Species name	4.9 Language 1= Luhya 2=Swahili 3=English 99 = Other (Specify)	4.10 Number of years you have grown crop	4.11 If used for HH consumption, are the amounts produced sufficient to cover the family to the next harvest season? 1 = Yes, 0 = No, 3=N/a	Rank the contribution of the crop to the HH income and food security where 5 is highest contributor and 1 lowest contributor	
				4.12Rank for food security	4.13 Rank for HH income
Cereals					
Roots and tubers					
Legumes and pulses and nuts					
Vegetables					
Fruits					
Others					

C: Wild edible plant diversity

Now I would like to know if there are any edible plant species growing wildly in your plots/gardens and which you or any member of your household collects to use for food. Please list them

4.14 Species name	4.15 Language 1= Luhya 2=Swahili 3=English 99 = Other (Specify)	4.16 In which months is the plant harvested?	4.17 Frequency of consumption	
			Number	Every 1=Day 2=Week 3=Month 4=Year 99=Other, specify

D: Social seed Networks for Traditional Leafy Vegetables (TLVs)[9] and Legumes[10]

An important focus of this study is to understand the sources of seed and related knowledge regarding those seed. The following questions ask you about specific types of interactions with other farmers and experts

	4.18 What is your main source of seed for: 1=Own seed 2=Neighbor or fellow farmer 3=Local market 4=Extension service 5=Seed company/seed trader 6=Farmer group 7=NGOs 8=Family members 99=Other, specify	4.19 What is your main source of information about seeds of: 1 - Government extension workers 2 - NGOs 3 - Community meetings 4 - Farmer organizations 5 - Research stations/Researchers 6 - Religious groups 7 - Agri-service providers, seed companies 8 - Family members 9 - Neighbors 10 - Radio 11 -TV 12 - Newspaper/Bulletin 13 - Schools/Teachers 14 - Cell phone/Internet

[9] 1=Black nightshade (Lisutsa); 2 = Spider plant (Saga); 3 =Amaranth (Tsimboka), 4=Cowpeas (Kunde); 5 = Jute mallow (Murenda); 6 = Clotolaria (Mito)

[10] Beans, Green grams

		15 - Traditional knowledge 16- Agricultural Shows 17- Farmer Field Days 18 - Own experience 99 = Other, specify
Black nightshade (Lisutsa)		
Spider plant (Saga)		
Amaranth (Tsimboka)		
Cowpeas (Kunde)		
Jute mallow (Murenda)		
Clotolaria (Mito)		
Beans		
Grean grams		

4.20 Over the past two seasons which Sources have you obtained seed from? Who gave the seeds to you from that source? Which species (for TLVs) or varieties did you obtain from the source

Traditional leafy vegetables			**Beans**			**Green grams**		
Name of source	Name of person	Species obtained	Name of source	Name of person	Varieties obtained	Name of source	Name of person	Varieties obtained

4.21 Over the past two seasons, with which farmers ***in your village*** have you obtained seed of TLVs, beans or green grams from? Which species (for TLVs) or varieties did you obtain from the farmer?

Traditional leafy vegetables		**Beans**		**Green grams**	
Name of farmer	Species obtained	Name of farmer	Varieties obtained	Name of farmer	Varieties obtained

4.22 Over the past two seasons with which farmers ***outside your village*** have you obtained seeds of TLVs, beans or green grams from? From which sublocation/county were they? Which species (for TLVs) or varieties did you obtain from the farmer?

Traditional leafy vegetables			**Beans**			**Green grams**		
Name of farmer	Sublocation/county	Species obtained	Name of source	Sublocation/county	Varieties obtained	Name of source	Sublocation/county	Varieties obtained

4.23 Over the past two season with which farmers ***in your village*** have you supplied or given seed of TLVs, beans or green grams? Which species (for TLVs) or varieties did you give to the farmer?

Traditional leafy vegetables		**Beans**		**Green grams**	
Name of farmer	Species given	Name of farmer	Varieties given	Name of farmer	Varieties given

4.24 Over the past year, with which farmers ***outside your village*** have you supplied or given seeds of TLVs, beans or green grams to? From which sublocation/county were they? Which species (for TLVs) or varieties did you give to the farmer?

Traditional leafy vegetables			**Beans**			**Green grams**		
Name of farmer	Sublocation/county	Species given	Name of source	Sublocation/county	Varieties given	Name of source	Sublocation/county	Varieties given

4.25 In the past year, whom have discussed with about species of TLVs or varieties of beans or green grams to grow? From which sublocation/county were they? Which species (for TLVs) or varieties did you give to the farmer?

Traditional leafy vegetables			**Beans**			**Green grams**		
Name of farmer	Sublocation/county	Species discussed	Name of farmer	Sublocation/county	Varieties discussed	Name of farmer	Sublocation/county	Varieties discussed

4.26 Please tell me if any of the individuals you named is a member of your family by birth, by marriage or in your tribe: (check all that apply) (If there are duplicate names listed below, answer only for the first name.) As I repeat the names, tell me if the person is:	
Name of the individual	Related to you by: 1=birth/blood; 2=marriage; 3=tribe; a leader in the village or local community

Expert Network on seeds

4.27 An important part of this study is to understand how farmers interact with experts related to seed. The next few questions ask you to name experts from different government, NGO or private sector organizations you have been in contact with during the past year. The experts and organizations will not know that they have been named in this survey.

In the past year, whom have discussed with about species of TLVs or varieties of beans or green grams to grow? From which institution were they? Which species (for TLVs) or varieties did you give to the farmer?

Traditional leafy vegetables				**Beans**				**Green grams**			
Name of person	Institution	Species discussed	Discussed about 1=Traditional varieties 2=Improved varieties 3=Both	Name of farmer	Institution	Varieties discussed	Discussed about 1=Traditional varieties 2=Improved varieties 3=Both	Name of farmer	Institution	Varieties discussed	Discussed about 1=Traditional varieties 2=Improved varieties 3=Both

F: Livestock diversity				
4.28 Do you/your household rear any livestock?			1= yes 0=no ***→4.26***	
4.29 Species name	4.30 Language 1= Luhya 2=Swahili 3=English 99 = Other (Specify)	4.31 Use of animal/product 1=Consumption 2=Sale 3=Both	4.32 Frequency of consumption	
			Frequency	Every 1=Day, 2=Week, 3=Month, 4=Year, 99=Other, specify

H: Climate Smart Technology (CST) Adoption and usage											
4.33. Practice		4.34 Are you aware of [practice]? 1=Yes>>4.35 0=No>>Next practice	4.35 Are you using [practice] currently on your farm? 1=Yes>>4.40 , 4.41, 4.42 0=No>>Next practice, then 4.37, 4.38 etc	4.36 Which practices are the most Important ? **Mark (*) up to three practices from those marked YES in 4.34**	4.37 Did you use [practice] on your farm within the past 12 months even though you are not using it now? 1=Yes>>4.38 0=No>4.39	4.38 Why did you stop using [practice] on your farm? 1 – No improvement in production 2- Lack of time 3 – Lack labor 4 – Husband refused 5- Lack seeds/inputs 99 – Other, specify	4.39 Would you start using or reintroduce [practice] if you could? 1=Yes 0=No	4.40 What is your main source of information for [practice]? 1 - GoK extension workers 2 - NGOs 3 - Community meetings 4 - Farmer organizations 5 - Research stations/Researchers 6 - Religious groups 7 - Agri-service providers, seed companies 8 - Family members 9 - Neighbors 10 - Radio 11 -TV 12 - Newspaper/Bulletin 13 - Schools/Teachers 14 - Cell phone/Internet 15 - Traditional knowledge 16- Agricultural Shows 17- Farmer Field Days 18 - Own experience Other, specify	4.41Who made the final decision to start/stop using [practice]? 1 – Man 2 – Woman 3 – Both man and woman 4 – Male child 5 – Female child 6 – various members of hh	4.42 Who is/was primarily responsible for performing [practice]?
Kitchen garden	Raised beds										
	Double digging										
	5/9 and basket										
	Mandala garden										
	Portable gardens										
	Diagonal offset										
Main field	Cover cropping										
	Crop rotation										
	Liming/Ph control										
	Zero tillage/No tillage										
	Weeding										
	Intercropping										
	Mulching										
Other	Water storage/ harvesting										
	Agroforestry										

11.2.3. Household Decision Making

A: Participation in Household Agricultural Activities "Now I'd like to ask you some questions about your participation in certain types of work activities"							
5.1 Activity description		5.2 Who in the household decides whether to [ACTIVITY] DESCRIPTION]? 1 – Man 2 – Woman 3 – Both man and woman 4 – Male child 5 – Female child 6 – various members of hh	5.3 Who in the household takes care of the [ACTIVITY] DESCRIPTION]? 1 – Man 2 – Woman 3 – Both man and woman 4 – Male child 5 – Female child 6 – various members of hh	5.4 Has the household sold any products/produce from [ACTIVITY] DESCRIPTION]?in the last 12 months 1=yes 0=no ➔ Go to Next activity	5.5 Who in the household decides to sell the products/produce? 1 – Man 2 – Woman 3 – Both man and woman 4 – Male child 5 – Female child 6 – various members of hh	5.6 What was the total value received from all sales of the products/produce in the last 12 months? Record the total sales in KES	5.7 Who decides how the money from the sale of the products/produce is used? 1 – Man 2 – Woman 3 – Both man and woman 4 – Male child 5 – Female child 6 – various members of hh
a	Food crop farming: these are crops that are grown primarily for household food consumption						
b	Cash crop farming: these are crops that are grown primarily for sale in the market						
c	Livestock raising						
d	Chicken raising						
e	Kitchen gardening						
f	TLV farming						
g	Legume farming						
h	Non-farm economic activities (e.g. running small business, self-employment, buy-and-sell)						
B: Household Decision Making							

"Now I have some questions about making decisions about various aspects of household life."					
5.6 ACTIVITY		5.7 When decisions are made regarding [ACTIVITY] who is it that normally takes the final decision? **CIRCLE ALL APPLICABLE** NOTE: DO NOT ASK **B** IF SELF IS THE ONLY RESPONSE		5.8 To what extend do you feel you can make your own personal decisions regarding [ACTIVITY] if you want(ed) to?	
	ACTIVITY	**A**		**B**	
a	Getting inputs for agricultural production	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
b	The types of crops to grow	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
c	Whether to set up a kitchen garden	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
d	The types of TLVs to grow	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
e	The types of legumes to grow	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
f	Taking crops to the market (or not)	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
g	Chicken raising	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
h	The types of chicken to keep	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
i	Expenditures on food for daily consumption	1= Self 2= Partner/spouse 3=other HH member		1 = Not at all 2 = Small extend 3 = Medium extend	

		4=Other non-HH member 98 =Not applicable → skip to next activity		4 = To a high extend 97=Not applicable	
j	Diet of HH members (excluding small children)	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
k	Diet of small children (complementary foods)	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
l	Diet of women in the HH	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
m	Type of TLVs to be used for HH consumption	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
n	Amount of TLVs to be used for HH consumption	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
o	Type of legumes to be used for HH consumption	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
p	Amount of legumes to be used for HH consumption	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
q	Amount of chicken (eggs and meat) to be used for HH consumption	1= Self 2= Partner/spouse 3=other HH member 4=Other non-HH member 98 =Not applicable → skip to next activity		1 = Not at all 2 = Small extend 3 = Medium extend 4 = To a high extend 97=Not applicable	
C: Individual Leadership and Influence in the Community (Woman)					
	5.9 Question	5.10 Response options/Instructions A		5.11 Response options/Instructions B	
a	Do you feel comfortable speaking up in public to help decide on crop production techniques?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable	

b	Do you feel comfortable helping fellow men/women to decide on crop production techniques?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable	
c	Do you feel comfortable speaking up in public to help decide on poultry raising techniques?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable	
d	Do you feel comfortable helping fellow men/women to decide on poultry raising techniques?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable	
e	Do you feel comfortable speaking up in public on nutritional practices?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable	
f	Do you feel comfortable advising fellow men/women on nutritional practices?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable	
g	Do you feel comfortable speaking up in public on complementary feeding practices?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable	
h	Do you feel comfortable advising fellow men o/women on complementary feeding practices?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable	
C: Individual Leadership and Influence in the Community (Man)					
	5.9 Question	5.10 Response options/Instructions A		5.11 Response options/Instructions B	
a	Do you feel comfortable speaking up in public to help decide on crop production techniques?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable	
b	Do you feel comfortable helping fellow men/women to decide on crop production techniques?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable	
c	Do you feel comfortable speaking up in public to help	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages	

	decide on poultry raising techniques?	3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		97=Not applicable		
d	Do you feel comfortable helping fellow men/women to decide on poultry raising techniques?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable		
e	Do you feel comfortable speaking up in public on nutritional practices?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable		
f	Do you feel comfortable advising fellow men/women on nutritional practices?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable		
g	Do you feel comfortable speaking up in public on complementary feeding practices?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable		
h	Do you feel comfortable advising fellow men o/women on complementary feeding practices?	1 = No, not at all comfortable 2 = Yes, but with a great deal of difficulty 3 = Yes, but with a little difficulty 4 = Yes, fairly comfortable 5 = Yes, very comfortable		1 = Only people from my village 2 = People from my village and other villages 3 = Mostly people from other villages 97=Not applicable		

D: Group Membership (Woman)

5.12 Group Type	5.13 Is there a [GROUP] in your community? Yes ..... 1 No ..... 0 >> next group	5.14 Are you an active member of this [GROUP]? Yes ..... 1 No ..... 0 >> E	5.15 What is your role/position in this [group]? 1- Ordinary member 2- Treasurer/Vice treasurer 3- Secretary/Vice secretary 4-Organizing secretary 5- Chair/Assistant chair 99- Other, specify	5.16 How much input do you have in making decisions in this [GROUP]? 1 = No input 2 = Input into very few decisions 3 = Input into some decisions 4 = Input into most decisions 5 = Input into all decisions	5.17 Why are you not a member of this [GROUP]? 1 = Not interested 2 = No time 3 = Unable to raise entrance fees 4 = Unable to raise reoccurring fees 5 = Group meeting location not convenient 6 = Family dispute/unable to join 7 = Not allowed because of sex 8 = Not allowed because of other reason 99 = Other, specify
Group Categories	**A**	**B**	**C**	**D**	**E**

a	Agricultural / livestock/ fisheries producer's group (including marketing groups)					
b	Water users' group					
c	Forest users' group					
d	Credit or microfinance group (including SACCOs/merry-go-rounds/ VSLAs)					
e	Mutual help or insurance group (including burial societies)					
f	Trade and business association					
g	Civic groups (improving community) or charitable group (helping others)					
h	Local government					
i	Religious group					
j	Other women's group (only if it does not fit into one of the other categories)					
k	Other (specify)					

D: Group Membership (Man)

5.12 Group Type		5.13 Is there a [GROUP] in your community? Yes .....1 No .....0 >> next group	5.14 Are you an active member of this [GROUP]? Yes .....1 No .....0 >> E	5.15 What is your role/position in this [group]? 1- Ordinary member 2- Treasurer/Vice treasurer 3- Secretary/Vice secretary 4-Organizing secretary 5- Chair/Assistant chair 99- Other, specify	5.16 How much input do you have in making decisions in this [GROUP]? 1 = No input 2 = Input into very few decisions 3 = Input into some decisions 4 = Input into most decisions 5 = Input into all decisions	5.17 Why are you not a member of this [GROUP]? 1 = Not interested 2 = No time 3 = Unable to raise entrance fees 4 = Unable to raise reoccurring fees 5 = Group meeting location not convenient 6 = Family dispute/unable to join 7 = Not allowed because of sex 8 = Not allowed because of other reason 99 = Other, specify
	Group Categories	**A**	**B**	**C**	**D**	**E**
a	Agricultural / livestock/ fisheries producer's group (including marketing groups)					
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d	Credit or microfinance group (including SACCOs/merry-go-rounds/ VSLAs)					
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f	Trade and business association					
g	Civic groups (improving community) or charitable group (helping others)					
h	Local government					
i	Religious group					
j	Other women's group (only if it does not fit into one of the other categories)					
k	Other (specify)					