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SCALING UP CROP DIVERSIFICATION AMONG FARMING COMMUNITIES FOR FOOD SECURITY UNDER CLIMATE CHANGE: A CASE STUDY OF THE KENYAN PELIS PROGRAMME

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ABSTRACT

Climate change poses significant risks to food security globally with predictions of 10-20 % decline in rain-fed crop yields by 2050. Sub-Saharan Africa remains highly susceptible to food shortage since over 95 % of the region's total cropland is rain-fed. Kenya's overreliance on rain-fed agriculture predisposes the country to climate-induced food insecurity. Murang'a County in Kenya is experiencing climate change challenges manifested in prolonged droughts and floods. The consequences, are failed cropping seasons, soil erosion, landslides, altered crop suitability and a resurgence of human, livestock, crop pests, and diseases, culminating into food insecurity. This study was conducted with Kimandi-Wanyaga community in the Gatanga Sub-County in Murang'a County, Kenya. Residents are smallholder subsistence rain-fed farmers. The study explored the potential of up-scaling crop diversification under the Plantation Establishment and Livelihood Improvement Scheme (PELIS) for food security vis-à-vis climate change. The community's climate change coping strategies were explored to account for the need to up-scale crop diversification under PELIS. A mixed methods research design was applied whereby a systematic sampling method was used to select 281 household-heads. Three key informants were purposively selected and primary data were collected through a household survey, in-depth key stakeholder interviews, focus group discussions and on-farm trials. Quantitative data were analysed using descriptive and inferential statistics while qualitative data were analysed using thematic and content analysis. The study established that 92.9 % of the community perceived climate change and its impacts. They had adopted a combination of coping strategies most of which, were found to be informed by short-term survival and hence, considered inadequate for long-term adaptation. The PELIS approach had been piloted in Murang'a County and was found to be a promising strategy for crop diversification and food security among forest-adjacent communities. However, only 11 % of the studied community participated in the scheme. Therefore, the study endeavoured to work with the community to promote cultivation of traditional vegetables under PELIS for crop diversification and food security in the face of climate change. The PELIS beneficiaries who adopted cultivation of Black nightshade, Amaranths and Cowpeas managed to produce enough for household consumption and sale of surplus for income. The PELIS, therefore, possesses the co-benefits of climate change adaptation through crop diversification for food security and climate change mitigation through afforestation for carbon sequestration.

Key words: Climate change, Crop diversification, Food security, PELIS, Traditional vegetable

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INTRODUCTION

Climate change is unequivocal, and evidently impacting Africa with global warming [1]. Climate change will negatively impact global food security as prolonged droughts and floods directly or indirectly affect key food security pillars namely food availability, access, and utilization. Rural livelihoods, especially in Africa, dependent on climate-sensitive agriculture are most vulnerable [2]. Kenya has been experiencing severe food insecurity from frequent droughts and reduced rainfall, thereby denying over 10 million Kenyans access to the right quantity and quality of food [3]. Murang'a County in Kenya faces frequent droughts, floods, and drying waterways, which undermine local communities' agricultural production and food security. Kimandi-Wanyaga is a community adjacent to Kimakia forest in Ndakaini Location, Gatanga Sub-County in Murang'a County. Residents are largely smallholder subsistence rain-fed farmers operating under unpredictable weather patterns, which cause constant low crop yields and sometimes complete seasonal crop failure, resulting in persistent food shortage. The farmers perceived temperature and rainfall change impacts on their agricultural production. Despite efforts to cope with the adverse impacts, food security constraints still persist [4]. This indicates an adaptation gap.

The study explored the community's coping strategies to climate change impacts on their food production. It was revealed that although the community has adopted a mix of strategies to secure food sources, there remains a general lack of relevant and accurate information on available coping mechanisms for effective actions. Most coping strategies were informed by short-term survival considerations. Matching the community's coping responses with reported frequency, intensity, and duration of climate hazards, current coping challenges and long-term food production risks, most of their current coping strategies were considered unsustainable for long-term adaptation. The study identified Plantation Establishment and Livelihood Improvement Scheme (PELIS) as promising avenue for food security adaptation. The PELIS is a Kenyan farming system model initiated by the ministries of Forestry, Agriculture, Water and Irrigation under Participatory Forest Management (PFM) guidelines of Forest Act (2005) to boost food security for forest-adjacent communities. During the pilot project, crop production rose significantly in one season, and 100 percent tree survival and protection was achieved [4]. Despite the approach's proven sustainability in addressing food security among forest-adjacent communities in Murang'a County, majority of the households (89.0 %) in the area were not participating in the scheme.

The study also showed that despite the community awareness on the nutritional value of indigenous vegetables and their high abundance in the area, current uptake remained very low. The community preferred exotic temperate vegetables such as kale, cabbages and spinach. This study, therefore, considered cultivation of traditional vegetables to diversify crops under PELIS as a promising climate adaptation for food security amongst forest-adjacent communities.

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MATERIALS AND METHODS

Study area

The study was undertaken in the Kimandi-Wanyaga Sub-Location, Ndakaini Location, Kariara Ward, Gatanga sub-County in Murang'a County. Covering approximately 9.169 km^2. The study area is mainly inhabited by the Kikuyu community who are predominantly smallholder rain-fed subsistence farmers. The study area lies at an altitude of 2040 m above sea level within Lower Highland (LH_1) agro-ecological zone also known as the Tea-Dairy Zone characterized by permanent cropping possibilities dividable into a long to very long cropping season followed by a medium one. Mean annual temperatures vary from 15 ºC to 18 ºC with an annual average rainfall of 1700-2400 mm. Proximity to the Aberdares and Mt. Kenya makes the climate generally wet and humid, suitable for tea and dairy farming. Rainfall distribution is bimodal. Long rains fall in March to May and short rains from November to early January. April rainfall is highest in amount and reliability [5]. Over 95 % of arable land is under tea. Few farmers participate in PELIS, practiced in the nearby Kimakia forest. Over 35 % of the landscape is steep with slopes greater than 15 % and fragile soils susceptible to soil erosion and landslides [4].

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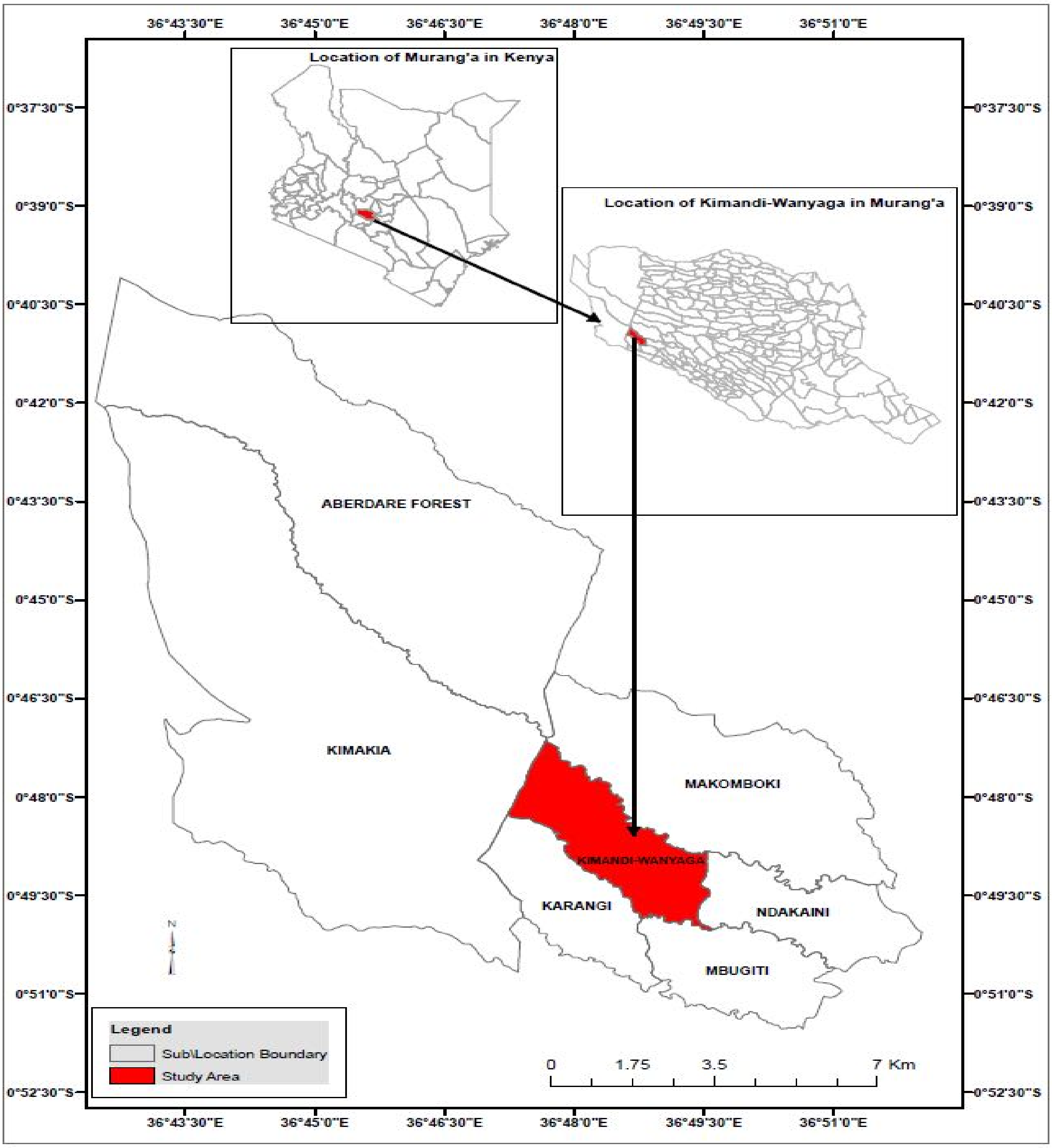

Figure 1: Location map of the study area in Murang'a County, Kenya [6]

Data Collection Methods

The study adopted a mixed methods research design. The sampling frame consisted of 943 Kimandi-Wanyaga Sub-Location households [7]. The Yamane formula at 95 % confidence level was used to derive the household survey sample of 281 households [8]. Sampled households were selected using systematic sampling method [9]. A probability inclusion range (sampling fraction) expressed as $= \frac{n}{N}$ where n is the sample size and N is the population size was determined as: $= \frac{281}{943}$ = 1/3 (0.33).

One in every three households took part in the study. Respondents were household heads (male or female). The diet diversity question was answered by the person in charge of family meal preparation.

Key informants were purposively selected based on knowledge requirement. Primary data were collected between August 2015 and January 2017 using semi-structured questionnaires in a household survey, key informant interviews, focus group discussions and on-farm trials. Quantitative data were analysed using descriptive statistics while qualitative data were analysed using thematic and content analysis and presented in tables, figures and direct quote formats.

The study explored the factors underlying the community's food shortage over the period 1984-2014. Determination of food availability and access was based on the period of consuming own produced food, number of meals consumed daily and dietary diversity. A 24-hour recall period of household food consumption was calculated using the Household Dietary Diversity Score (HDDS) [10] as a snapshot reflection of the households' economic ability to access different foods. A household dietary diversity questionnaire adapted to Kimandi-Wanyaga context was used to count the food groups a household had consumed during the preceding 24 hours.

The household's coping mechanisms against crop production disruptions associated with perceived rainfall and temperature variations were explored. Also examined was the potential of PELIS as a food security coping strategy in the area. To this end, the study sought to promote cultivation of selected traditional vegetables as a strategy for crop diversification for food security under PELIS. The vegetables included, Cow peas *(Vigna unguculata)* *Managu (Black nightshade)* *Terere (Amaranth spp.)* *Saget (Cleome gynandra)* and *Murenda (Corchorus olitorius)*. Two field trials on the vegetables cultivation were conducted to advance skills on land preparation, proper spacing, fertilizer application, field management, harvesting, cooking, nutritional value and value addition through drying to lengthen shelf life (Figure 2). A pairwise preference ranking exercise was conducted for the farmers to select their preferred vegetables (Table 6). Follow-up visits to farmers who participated in the field trials were conducted to explore uptake and use of the vegetables (Table 7).

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a) Improved Black night shade vegetable

b) Traditional Amaranth vegetable

c) Training on the vegetables nutritional value

d) Preservation of the vegetables by drying

Figure 2(a-d): Photographs of various stages of a field trial on cultivation of selected traditional vegetables at Wanyaga

RESULTS AND DISCUSSION

Characteristics of the Smallholder Farming Communities

Majority of household respondents were middle-aged males (Table 1). The effect of gender of household heads on adaptation is two-pronged. First, male household heads are less risk averse and, therefore, likely to undertake new adaptation technologies faster than female household heads [11]. Male-headed households are more likely to adopt agricultural technologies [12]. Conversely, the study established that females in the study area spent approximately 37.5 % of their work schedule, working on the farm compared 25 % for males. However, since high resource endowment favours climate change adaptation, the inability of women to access empowerment resources such as education, finance and land undermines their climate change adaptive capacity. Hence, gender and uptake of new technologies can be regarded as context-specific.

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The results of the study also indicated high literacy levels (62.2 %) among the household heads, the majority of whom were males (76.2 %). High literacy levels increase the probability of climate change adaptation. More educated household heads are more likely to adopt improved and climate change adaptation technologies [13]. Higher literacy levels increase farmers' accessibility to information on new technologies hence better productivity [14]. Most of the household heads were also middle-aged (69.4 %). Reluctance of older farmers to adopt new climate change technologies has been noted [15]. Agronomic superiority, farmers' attitudes and perceptions determine technology adoption [16]. However, other studies relate years of farming experience to increased uptake of new agricultural technologies. Approximately 59.4 % of households had farm sizes of less than two hectares. Declining household farm sizes as population increases undermines adoption of some viable climate-coping strategies among smallholder farming communities [14, 17].

Factors Underlying Food Insecurity

From the household survey, 61.9 % of respondents indicated that in the past one year, their household members had experienced hunger and 68.0 % ran short of money to buy food. During the previous one month (July, 2015), 71.2 % of respondents had run out of money to buy food for more than 5 days. Regarding the period of consuming own produced foods, survey results indicated that 38.8 % of respondents indicated a month, 40.2 % indicated two months, 20.6 % indicated three months and 0.4 % indicated six months. One key informant added that:

"Majority of farmers here do not produce enough food to last to the next season. Little efforts are put on food crop farming. People buy food between seasons from neighbouring Nyandarua County."

On daily household consumption, study findings showed that 71.5 % of respondents consumed two meals, 27.1 % consumed three meals and 1.4 % consumed four meals daily. Study results also indicated that 71.9 % of respondents had observed a rise in food shortage over the period 1984 to 2014 due to varying reasons (Table 2).

One FGDs participant reiterated:

"Weather changes have reduced crop yields especially maize and brought food shortage. In the past, we used to harvest enough maize to last almost all year round. Every home had a granary for storing excess maize which was dried in the sun and stored for making Githeri (boiled maize and beans) and porridge. A lot of foods were cooked and stored in outside granaries which were unlocked for free access to family members and visitors. This generosity was due to plentiful of food those days. Nowadays there are no granaries."

The community's main source of livelihood was smallholder rain-fed agriculture (83.3 %), making their livelihoods highly susceptible to erratic weather patterns. Majority of the farmers had experienced persistent food shortages and finance inadequacy arising from among other factors, unfavourable weather. Their own- produced food could hardly reach the next season and majority of the farmers only consumed two meals daily. Rural

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households' livelihoods in majority of developing countries are highly agriculture-dependent, mainly from crop and livestock goods' sales and the value of goods produced and consumed by the households [18]. It is noted that household income sources highly dependent on agriculture are the most sensitive to climate change. Climate change is projected to indirectly affect prices and availability of food and agricultural-generated income at national and farm levels [19]. Studies have established the importance of rain, to rain-fed farming communities also observing that some farmers attribute low crop production to climate variability [20, 21].

Low dietary diversity was also observed among the study community (Tables 3 and 4). Low dietary diversity, "hidden hunger", occurs when people suffer deficiency of vital micronutrients leading to human development retardation despite consumption of sufficient calories [22]. Agricultural biodiversity has been associated with diet quality and diversity among farming communities in Malawi [23]. Biodiversity changes may influence diversity of foods available from own production, local markets and gathering. A positive relationship has been found between households' diet diversity and diversity of own farm production in East Africa [24]. Traditional vegetables are rich in micronutrients and can contribute to food security, particularly, during food shortages [25]. Therefore, there is need to expand diversification especially through production and consumption of high value vegetables.

Climate Coping Strategies

Perceived climate change impacts had rendered crop farming alone inadequate for sustainable food security, forcing the farmers to adopt a mix of climate coping strategies (Figure 3). In concurrence were Murang'a County reports that farmers in the county practiced a range of strategies to cope with climate change impacts on food production [4]. Among the preferred climate coping strategies were change of crop types, use of local landraces and expansion of food crop farming area. To supplement their farm income, they had diversified to non-farm income sources. Findings from the FGDs respondents were that farmers staggered maize planting, planted maize between rows of mature maize crop or intercropped maize with beans and potatoes. Some farmers planted early maturing crops such as capsicum, courgettes and spinach to escape drought, while others intercropped tree tomatoes with tea. Some male farmers had formed an avocado marketing group to curtail middlemen exploitation. One farmer was progressively replacing his tea crop with more profitable Hass avocado trees. Kales were grown in kitchen gardens. Studies show that few households fully depend on agriculture because variability of agricultural production has led many to diversify their income sources and depend less on agriculture. In Kenya, for example, it has been observed that smallholder farmers apply a combination of strategies to cope with climate change [26, 27, 28].

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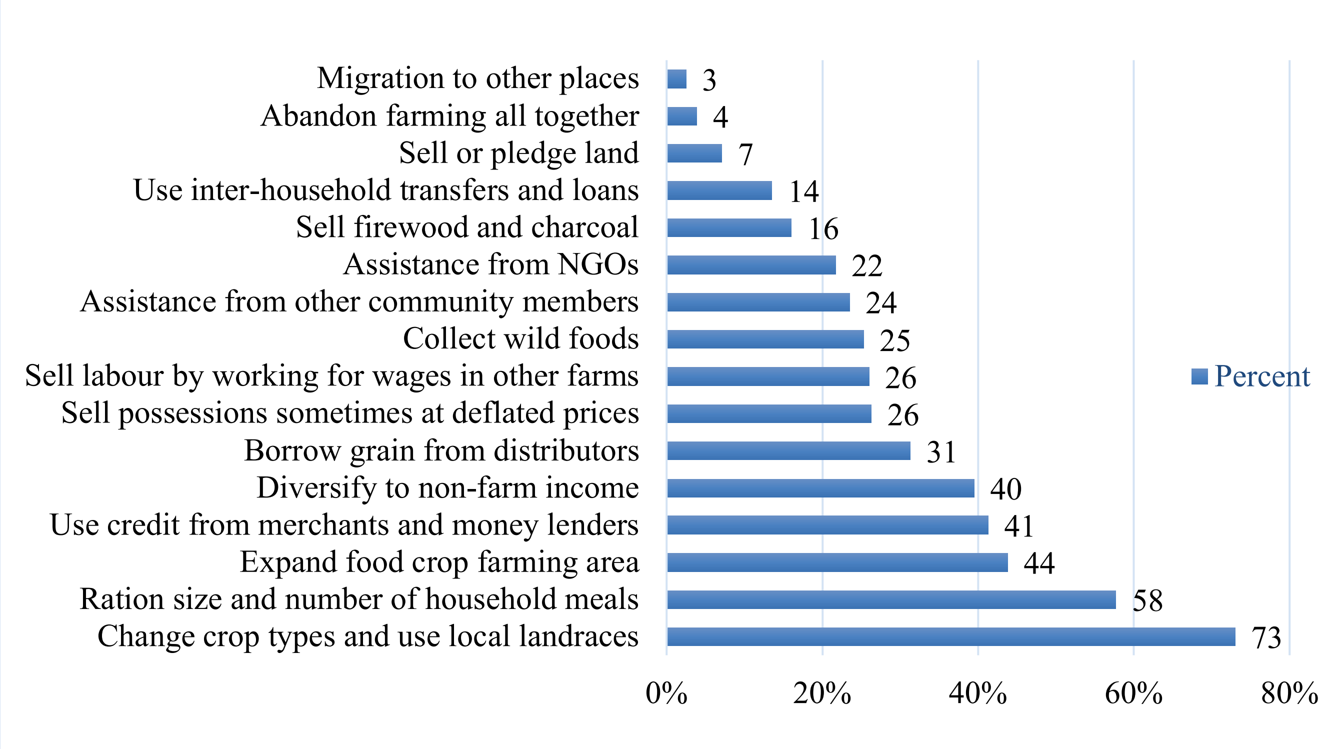

Figure 3: Climate change coping strategies practiced [6]

Based on perceived frequency, intensity, duration of climate hazards and the current adaptation challenges, some of the community's coping strategy responses (such as sale of firewood, charcoal, land and other possessions at deflated prices together with food rationing) were found to be erosive and could lead to maladaptation. The strategies adopted by the community before the PELIS intervention were considered inefficient for long-term adaptation since they were informed by short-term survival considerations resulting from inadequate information/awareness on available coping mechanisms/interventions. This observation indicated future vulnerability to food insecurity. It is argued that inadequacy of resources to proactively manage risk and engage in long-term commitments forces resource-poor people to rely on short-term plans [29]. Moreover, coping strategies informed by weak foresight and short-period sustenance considerations weaken future adaptive capacity by endangering environments and narrowing livelihood choices [30]. Therefore, the farmers required affordable options to match their low adaptive capacity.

Relating adaptive capacity to responsiveness of agricultural systems to extreme conditions such as climate change, human systems are more adaptable if they possess flexibility to switch to alternative land use within agricultural systems. In most poor countries, many rural households are net food consumers, spending non-farm income to buy what they need but cannot produce [31]. They benefit when prices fall and suffer if climate change raises food prices. Farmers can also respond to higher food prices by expanding their production to other farms, become net food sellers and raise agricultural wage labour demand [18]. Farmers' entitlements are the means of food production (land, labour and capital) at their disposal and their food access is certain if they can amply

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command these factors for sufficient food production [26]. The PELIS, therefore, presented alternative land for farmers to diversify their food production. Results of the two field trials in this study (Table 7) show that the PELIS farmers who adopted cultivation of the traditional vegetables managed to produce enough for home consumption and surplus for sale.

Motivation for the Community to Grow Traditional Vegetables

The study also found out that the farmers were well aware of the value of indigenous vegetables (Table 5). However, cultivation of the vegetables such as black nightshade (*Solanum nigrum*) and amaranth (*Amaranth sp.*) remained very low due to stigma associated with these vegetables. The vegetables wildly perpetuated themselves from where the farmers harvested them. In spite of their abundance and high nutritional value, the study showed that during the period 1984 to 2014, only a paltry 2.85 % of the farmers had grown black nightshade while no farmer had grown amaranth. It was also observed that the community's food habits favoured exotic temperate vegetables such as kale and spinach, while they considered indigenous vegetables as poor man's food only to be consumed during famine. Farmers neglected, stigmatized and denoted indigenous vegetables as weeds and uprooted them to plant other crops. This was corroborated by the preference ranking results (Table 6) which showed low preference for amaranth (*Amaranth sp.*) and black nightshade (*Solanum nigrum*). Pressure to expand farming land had also led to gradual disappearance of the indigenous vegetables, hence the need to domesticate them. A tour to the local markets and seed dealers revealed that indigenous vegetable seeds were not being sold. Other studies confirm that although indigenous vegetables play a key role in most rural Kenyan diets due to their rich micronutrient content, medicinal value, and many agronomic and economic advantages, their potential remains undervalued owing to their low reputation status. Despite their considerable yield potential, their acceptance remains low, hence their partial domestication. Most of them are considered weeds. Youthful communities also prefer exotic to traditional vegetables [24, 32].

Crop Diversification and the PELIS Programme

In Kenya, the Plantation Establishment and Livelihood Improvement Scheme (PELIS) is a farming system aimed at improving food production among forest-adjacent communities [4]. In the study area, participation in PELIS requires payment of an annual registration fee of 700 Kenya shillings to Kenya Forest Services (KFS) and 200 Kenya shillings to Kimakia Community Forest Association (CFA). Farmers are allocated land parcels through balloting. Each ballot is equivalent to one acre and farmers can have more than one ballot depending on land availability and affordability. Farmers cultivate the land for one year after which, KFS provides them with tree seedlings to plant and manage alongside their food crops. The main trees planted are cypress *(Cypressus lusitanica)* and Pine *(Pinus pinea)*. Crops such as maize, carrots, peas, beans, and potatoes are cultivated until the trees form a canopy after which, they are left to grow undisturbed. However, despite the practice's proven effectiveness in addressing food shortage in the county, only 11 % of the sampled households were participating in the scheme. Among the reasons cited by non-participants were unawareness of PELIS, living far from the forest and lacking money to register. Approximately 90.3 % of the PELIS participants aimed to increase their household food sources and income, 3.2 % had been

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trained and funded to manage trees and 6.5 % were employed by the Community Forest Association (CFA). Activities in PELIS included tree nursery establishments, planting pine trees for sale and, growing food crops for home consumption and sale. The PELIS beneficiaries reported sustained bumper harvests, which led them to form marketing groups to bulk their produce and hire pick-up vehicles to transport the produce to neighbouring boarding schools, hospitals and large markets. These findings aligned with the study objective of scaling up the community's crop diversity under PELIS for food security.

With an aim to avert the negativity associated with indigenous vegetables among the community, the study conducted field trials (Figure 2) to promote cultivation of selected improved traditional vegetable varieties. Due to small farm acreage holding, most farmers planted Black nightshade and Amaranths on small patches of land, which only yielded enough for home consumption and little surplus to sell to local markets. The PELIS participating farmers with access to larger farms (one acre) who cultivated the vegetables alongside other crops, were able to produce enough volumes to supply to local schools, hospitals and large towns such as Thika (Table 7). Indigenous vegetables' optimal yield level ranges from 20 to 40 tonnes per hectare per season, achievable through use of high quality seed under environment-friendly growing conditions and utilization techniques (spacing, right rates of organic/inorganic fertilizers) [24]. The household survey results (Table 5) confirm that the community was aware of the benefits of indigenous vegetables. In Ghana, urban households consume dark green leafy vegetables to diversify their diets [33]. In Kenya, the nutritional value of traditional vegetables including Amaranth and Black nightshade is reported [34, 35]. Production and consumption of the nutrient-rich vegetables presents the dual-purpose potential of improving dietary diversity and economic prowess of rural farming communities.

CONCLUSION

The results of this study showed that the participants perceived that their crop productivity was declining as a consequence of climate change and variability impacts leading to food insecurity. The PELIS emerged as a new adaptation avenue with significant potential to enhance the community's food security. Ready access to larger parcels of land under PELIS could enable the farmers expand their crop diversity by incorporating improved traditional vegetables such as Black nightshade, Amaranths and Cowpeas for diet diversity and income generation. However, only 11 % of respondents in the study area were participating in the scheme. Scaling-up PELIS was constrained by unawareness on how to participate in PELIS, inadequate finances and market inaccessibility. The study also identified inadequate knowledge on the cultivation of the vegetables as a challenge.

To address these challenges calls for concerted efforts by the government to promote PELIS awareness among forest-adjacent communities in the County. Collaboration is also needed among relevant value chain key stakeholders including local farmers, researchers, input providers, creditors, transporters, processors, governmental and non-governmental organizations to enhance production, consumption and marketing of traditional vegetables. This strategy will avert the negativity associated with the vegetables, promote their great potential in contributing to food and nutrition security and improve incomes among farming communities across Africa and beyond. The following policy and adaptation recommendations supported by the findings from this study are suggested:

- Enhanced sensitization and training on PELIS functionality among forest adjacent communities. This is achievable by engaging the public more frequently through knowledge-sharing and learning platforms such as local administration meetings *(barazas),* farmer field days and workshops.
- Enhanced knowledge transfer on domestication and nutritional value of traditional vegetables for dietary diversity among smallholder farming communities and complementary institutions such as hospitals and schools. This is possible through multiple capacity building platforms such as farmer field days, workshops, local administration meetings *(barazas)* and local media.
- Introduction of measures that enhance women access to production factors such as land, credit, extension services and labour. Women social capital should be harnessed as a necessary and sufficient conduit for acquisition of requisite knowledge and information for successful and sustainable implementation of relevant and appropriate climate coping strategies such as commercial agriculture. Fostering gender equality at household and community level entails, empowering women and girls through education, skills training and enrolment in cooperatives. Empowered women are able to compete for off-farm employment opportunities. Introduction of cost-effective labour-saving technologies, could also ease women's burden of work, and enable them to attend meetings and be included in decision making processes.

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Authors' Contributions
The study was conducted by Mary Wangui Ngure as part of her Ph.D. thesis, with the guidance of Professor Shem Wandiga, Professor Daniel Olago and Dr. Silas Oriaso. They supervised field work, contributed ideas and thoroughly reviewed thesis drafts. They read and contributed ideas on the manuscript development to conclusion. All authors read and approved the final manuscript.

Competing Interests
The authors declare no competing interests.

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Table 1: Characteristics of the population in the study area [6]

Characteristic		Percentage
Age (years)	>25	0.4
	25-35	12.1
	36-45	27.8
	46-55	29.5
	56-65	16.4
	66-75	7.8
	76-85	3.9
	<85	2.5
Gender	Male	76.2
	Female	23.8
Formal Education Level	None	8.9
	Primary	28.8
	Secondary	52.7
	College/University	9.5
Household Farm Acreage	0-0.5	6
	0.51-1.0	19.6
	1.01-1.5	17.8
	1.51-2.0	16
	2.01-2.5	16
	2.51-3.0	10.3
	3.01-3.5	2.5
	3.51-4.0	5
	4.01-4.5	2.1
	4.51-5.0	2.1
	5.01-5.5	1.1
	5.51<	1.4
Household farm uses	Cash Crop	67.34
	Food Crops	20.59
	Homestead	12.07
Household head occupation	Farming only	83.3
	Farming and informal employment	8.9
	Farming and formal employment	7.8

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Table 2: Perceived reasons for recurring food shortage (n=281) [6]

Food shortages	Frequency	Percent
Unpredictable seasons due to unreliable rainfall, prolonged droughts, high temperatures and sometimes long cold spells.	101	35.9
Poor soil fertility and high soil acidity	32	11.4
High outbreaks of crop pests and diseases	27	9.6
Unstable income to exploit full farm potential	17	6.0
Small land for growing crops hence continuous cropping	24	8.5
Poor crop varieties	12	4.3
Low crop yields	23	8.2
Variable seasonal yields	21	7.3
Low seed quality	14	5.0
Reduced river water for irrigation	10	3.6
Total	**281**	**100.0**

Table 3: Food categories consumed (n=281) [6]

Food category consumed	Count	Percent
Cereals	232	82.6
Fish	17	6.0
Root and tubers	165	58.7
Legumes/nuts	156	55.5
Vegetables	170	60.5
Milk and milk products	123	43.8
Fruits	87	31.0
Oil/fats	184	65.5
Meat/poultry	86	30.6
Sugar/honey	189	67.3
Eggs	66	23.5
Miscellaneous food items	148	52.7

N.B. Multiple Responses Frequency Table

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Table 4: Household Dietary Diversity Score [6]

	N	Minimum	Maximum	Mean	Std. Deviation
HDSS	281	2	7	4.0036	1.11323

Table 5: Motivating reasons for growing indigenous vegetables (n=281) [6]

Reasons for growing indigenous vegetables	Frequency	Percent
Market responsiveness i.e. highly marketable currently	23	8.2
Rich nutritional value hence recommended for patients	112	39.9
Require minimal farm management	56	19.9
They grow naturally	14	5.0
Long harvesting periods & high yields	17	6.1
Fast growing than exotic vegetables	21	7.5
Drought tolerant	11	3.9
Require less inputs e.g. fertilizers and chemicals	12	4.3
Resistant to pests and diseases	9	3.2
Adaptable to different climatic conditions	6	2.1
Total	**281**	**100.0**

Table 6: Selected traditional vegetables pairwise preference ranking results [6]

Vegetable	Winner Score	Ranking
Cowpeas *(Vigna unguiculata)*	4	1
Managu (Black nightshade)	2	2
Terere (*Amaranth spp.*)	1	3
Saget (Cleome gynandra)	0	4
Murenda **(***Corchorus olitorius)*	0	4

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Table 7: Results of the two field trials conducted [6]

Seasons	No of farmers	Vegetables planted	Outcome	Use
1	22	*Terere (Amaranth spp.) Managu (Black nightshade) Cowpeas (Vigna unguiculata) Saget (Cleome gynandra)*	*Terere (Amaranth spp.) Cow peas (Vigna unguiculata) and Managu (Black nightshade)* grew well under PELIS. *Cow peas (Vigna unguiculata)* grown on non-PELIS farms developed poorly hence low yields.	7 PELIS farmers sold to schools and local markets. 15 non-PELIS farmers grew for family use and sold to neighbours only.
2	21	*Terere (Amaranth spp.) Managu (Black nightshade) Cowpeas (Vigna unguiculata) Saget (Cleome gynandra)*	*Terere (Amaranth spp.) Cow peas (Vigna unguiculata) and Managu (Black nightshade)* grew well under PELIS. Only *Terere (Amaranth spp.)* and *Managu (Black nightshade)* grew well on non-PELIS farms	7 PELIS farmers sold to schools, hospitals and Thika market. 14 non- PELIS farmers grew for family use and sold to local green grocers.
3	21	*Terere (Amaranth spp.) Managu (Black nightshade) Cowpeas (Vigna unguiculata) Saget (Cleome gynandra)*	*Terere (Amaranth spp.) Cow peas (Vigna unguiculata) and Managu (Black nightshade)* grew well under PELIS. The variety of *Terere (Amaranth spp.)* planted on non-PLELIS farms flowered early. It was uprooted and a new variety planted. *Cow peas (Vigna unguiculata)* grew poorly. *Managu (Black nightshade)* and *Saget (Cleome gynandra)*grew well but	7 PELIS farmers sold to Thika market. 14 non-PELIS farmers had low *Terere (Amaranth spp.)* yields only for family consumption. *Saget (Cleome gynandra)*and *Managu (Black nightshade)* sold to local green grocers
4	22	*Terere (Amaranth spp.) Managu (Black night shade) Cowpeas (Vigna unguiculata) Saget (Cleome gynandra)*	New variety of *Terere (Amaranth spp.)* planted. *Terere (Amaranth spp.) Managu (Black nightshade) Cow peas (Vigna unguiculata)* and *Saget (Cleome gynandra)* grew well under PELIS. *Managu (Black nightshade)* seeds from previous crop were planted.	7 PELIS farmers harvested enough to sell to nearby schools. 15 Non-PELIS farmers produced enough for family consumption and sell surplus to local markets.

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REFERENCES

1. **Collier P, Conway G and T Venables** Climate Change and Africa. Oxford Review of Economic Policy, 2008; **24(2)**: 337- 353.

2. **Lobell DB, Burke1 MB, Tebaldi C, Mastrandrea MD, Falcon WP and RL Naylor** Prioritizing Climate Change Adaptation Needs for Food Security in 2030 *Science,* 2008; **319 (58630)**: 607-610.

3. **WFP, FAO, IFAD.** The state of food insecurity in the world. Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition, 2012.

4. **Murang'a County Integrated Development Plan** Kenya Vision 2030. Towards a Globally Competitive and Prosperous Nation, 2013-2017. https://cog.go.ke... *Accessed 03/10/2018.*

5. **Jaetzold R and H Schmidt** Farm Management Handbook of Kenya: Natural Conditions and Farm Management Information. Ministry of Agriculture, Nairobi, 1983; 411 pp.

6. **Ngure MW** Enhancing Food Security through crop and livelihood diversification among Kimandi-Wanyaga community in Murang'a County, Kenya. Ph.D. Thesis, University of Nairobi, 2020.

7. **KNBS.** The 2009 Kenya Population and Housing Census. Kenya Ministry of State for Planning, National Development and Vision 2030.Government Printer, Nairobi, 2010; 297pp. Available at: https://www.knbs.or.ke/?p=5621 *Accessed on 14th February 2014.*

8. **Yamane T** Statistics: an introduction analysis, Harper & Row, 1973.

9. **Bryman A** Social research methods. Oxford university press. U.K., 2016; 748 pp.

10. **Swindale A and P Bilinsky** Household dietary diversity score (HDDS) for measurement of household food access: indicator guide. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development, 2006.

11. **Asfaw A and A Admassie** The role of education on the adoption of chemical fertilizer under different socioeconomic environments in Ethiopia. *Agricultural economics*, 2004; **30(3)**: 215-228.

12. **Buyinza M and N Wambede** Extension for agroforestry technology adoption: mixed intercropping of crotolaria (Crotolaria grahamiana) and maize (Zea mays L.) in Kabale district, Uganda. *Environmental Research Journal*, 2008; ***2*(3)**: 131-137.

13. **Maddison D** The perception of and adaptation to climate change in Africa. CEEPA. Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa. Pretoria, South Africa: University of Pretoria, 2006.

14. **Mignouna B, Manyong M, Rusike J, Mutabazi S and M Senkondo** Determinants of Adopting Imazapyr-Resistant Maize Technology and its Impact on Household Income in Western Kenya: AgBioforum, 2011; **14(3)**: 158-163.

15. **Shongwe P, Masuku MB and AM Manyatsi** Factors influencing the choice of climate change adaptation strategies by households: a case of Mpolonjeni Area Development Programme (ADP) in Swaziland. *Journal of Agricultural Studies*, 2014; **2(1):** 86-98.

16. **Opole R** Opportunities for enhancing production, utilization and marketing of Finger Millet in Africa. *Afr. J. Food Agric. Nutri. and Dev.*, 2019; **(1)**: 13863-13882.

17. **Kebede Y, Gunjal K and G Coffin** Adoption of new technologies in Ethiopian agriculture: the case of Tegulet-Bulga District, Shoa Province. Agricultural Economics: The Journal of the International Association of Agricultural Economists, 1990; **4 (968-2016-75386)**: 27-43.

18. **Taylor JE and I Adelman** Agricultural household models: genesis, evolution, and extensions. Review of Economics of the Household, 2003; **1(1-2):** 33-58.

19. **Hachigonta S, Nelson GC, Thomas TS and LM Sibanda** Southern African Agriculture and Climate Change: A comprehensive analysis. International Food Policy Research Institute, Washington, DC., 2013.

20. **Agesa BL, Onyango CM, Kathumo VM, Onwonga RN and GN Karuku** Climate change effects on crop production in Yatta sub-county: farmer perceptions and adaptation strategies. *Afr. J. Food, Agric. Nutri. and Dev.,* 2019; **19 (1)**: 14010-14042.

21. **Atedhor GO** Agricultural vulnerability to climate change in Sokoto State, Nigeria. Afric. *J. Food. Agric. Nutri. and Dev.*, 2015; **(2)**: 9855-9871.

22. **Pinstrup-Andersen P (Ed)** The African food system and its interaction with human health and nutrition. Cornell University Press, 2010.

23. **Jones AD, Shrinivas A and R Bezner-Kerr** Farm production diversity is associated with greater household dietary diversity in Malawi: findings from nationally representative data. *Food Policy*, 2014; **(46)**: 1-12.

24. **Herforth A and S Ahmed** The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. *Food Security*, 2015; **7 (3)**: 505-520.

25. **Abukutsa-Onyango MO** Unexploited potential of indigenous African vegetables in Western Kenya. *Maseno Journal of Education Arts and Science*. 2003; **4(1)**: 103-122.

26. **Eakin HC, Lemos MC and DR Nelson** Differentiating capacities as a means to sustainable climate change adaptation. *Global Environmental Change*, 2014; **(27)**: 1-8.

27. **Davies M, Guenther B, Leavy J, Mitchell T and T Tanner** Climate change adaptation, disaster risk reduction and social protection: complementary roles in agriculture and rural growth? IDS Working Papers, 2009; **(320)**: 1-37.

28. **Ogalleh SA, Vogl CR, Eitzinger J and M Hauser** Local perceptions and response to climate change and variability: The case of Laikipia District, Kenya. *Sustainability*, 2012; **4(12)**: 3302-3325.

29. **Gandure S, Walker S and JJ Botha** Farmers' perceptions of adaptation to climate change and water stress in a South African rural community. *Environmental Development*, 2013; **5**:39-53.

30. **Robledo C, Clot N, Hammill A and B Riché** The role of forest ecosystems in community-based coping strategies to climate hazards: Three examples from rural areas in Africa. *Forest Policy and Economics*, 2012; **24**:20-28.

31. **Ritzema RS, Frelat R, Douxchamps S, Silvestri S, Rufino MC, Herrero M, Giller KE, Lopez-Ridaura S, Teufel N, Paul BK and MT Van Wijk** Is production intensification likely to make farm households food-adequate? A simple food availability analysis across smallholder farming systems from East and West Africa. *Food Security*, 2017; **9 (1)**: 115-131.

32. **Hijmans RJ, Cruz M, Rojas E and L Guarino DIVA-GIS, version 1.4.** A geographical information system for the analysis of biodiversity data. Manual. International Potato Centre, Lima, Peru, 2001. Available at: http://www.cgiar.org/research-centers/cip/ *Accessed on 17th June 2014.*

33. **Chagomoka T, Drescher A, Glase R, Marschner B, Schlesinger J and G Nyandoro** Vegetable production, consumption and its contribution to diets along the urban–rural continuum in Northern Ghana. *Afric. J. Food. Agric. Nutri. and Dev.,* 2015; **(4)** :10352-10367.

34. **Mwanga R, Kebede SW and W Bokelmann** Protein and energy contribution of African indigenous vegetables: Evidence from selected rural and peri-urban counties of Kenya. *Afr. J. Food Agric. Nutr. Dev.*, 2020; **20 (1)**: 15177-15193.

35. **Kirigia D, Winkelmann T, Kasili R and H Mibus** "Development stage, storage temperature and storage duration influence phytonutrient content in cowpea (Vigna unguiculata L. Walp.)."*Heliyon.* 2018; **4 (6)**: e00656.