FINAL REPORT

ACCELERATING ACTION RESEARCH FOR SMALLHOLDER AGRICULTURE ADAPTATION IN KENYA

January 2025

Acknowledgements

We appreciate the Adaptation Research Alliance for giving us the opportunity to carry out this co-creation action towards identifying action-oriented research priorities in agriculture for smallholder farmers in Kenya. We likewise extend our sincere gratitude to the Bill & Melinda Gates Foundation for funding this work. We have been keen on influencing research in our region by incorporating local context needs and this piece of work allowed us to create opportunities for funders to benefit from first-hand information from smallholder farmers. We extend our sincere appreciation to the staff of the African Group of Negotiators Experts Support (AGNES) for providing their invaluable technical, administrative and logistical support making working on this project quite smooth. Our appreciation goes too to the Kenya Meteorological Department for technical and logistical support and to the County Directors for honouring our invitations to the workshops and being very active participants. The Advisory Committee constituted to provide guidance was very invaluable in refining our approaches and ideas, and we extend our sincere gratitude to each of them. To everyone who worked tirelessly in most cases to ensure that we deliver the project, we offer our appreciation.

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Executive Summary

Kenya's climate, like most countries in the Horn of Africa, is highly variable, both in time and space, making it prone to extreme climate events. Over the past decade, the frequency and severity of these extremes have become more evident as the climate continues to warm. Agriculture is a cornerstone of Kenya's economy, contributing 26% directly and 25% indirectly to the GDP annually. It accounts for 65% of total exports and provides over 70% of informal employment. Agriculture is practiced at both subsistence and commercial scales, primarily in rural areas but increasingly in urban settings. This sector is not only a driver of Kenya's economy but also a vital means of livelihood for the majority of the population. The country has seven agro-climatic zones, determined by moisture, temperature, and rainfall profiles, influence the crops grown and livestock reared in each region. These zones experience climate impacts differently, influenced by factors such as land tenure systems, economic conditions, and cultural values *inter allia*.

The agriculture sector is highly vulnerable to climate change, which drives increased weather variability, including frequent droughts, flash flooding, erratic rainfall patterns and rising temperatures, impacting productivity, crop and livestock pests and diseases, labor efficiency, the cost of farm inputs and exacerbating poverty and resource-based conflicts. Smallholder farmers make up the bulk of contributors to the agricultural sector in Kenya, with most practicing a mixed crop and livestock farming system as well as small-scale fishing in the many lakes in the country and the Indian Ocean bordering the country to the East. These smallholder farmers are at the front line of climate change impacts due to their limited access to resources, information and other anticipatory actions. Urgent adaptation measures are needed to secure lives and strengthen livelihoods, particularly for smallholder farmers. It is there important to support smallholder farmers with targeted interventions that are tailored to specific local circumstances to ensure they are adapting to and reducing risks from climate change, Co-creation processes are essential for understanding the context-specific challenges faced by smallholder farmers and designing appropriate, robust response measures.

The **co-creation process aimed to establish a participatory locally led framework for identifying and prioritizing research areas that support the adaptation of smallholder farmers to climate change**. This was achieved through a series of Six (6) structured workshops at both national and sub-national levels, ensuring alignment with policy priorities while integrating local insights and actionable strategies. A total of **two (2) national-level workshops** were conducted to engage stakeholders across agriculture-linked sectors, government agencies, and departments. These workshops served to: Establish national climate adaptation priorities in agriculture; Align research focus areas with existing national policies; Provide a platform for a coordinated and inclusive engagement approach allowing feedback loops from sub-national workshops; and Prioritization of identified research areas in line with national policy priorities. By convening key actors at the national level, the workshops facilitated a comprehensive understanding of adaptation needs for smallholder farmers, ensuring that research priorities were strategically integrated within broader policy frameworks.

Additionally, **four (4) sub-national workshops** were organized across Kenya's main agroecological zones to capture region-specific agricultural challenges, adaptation gaps, needs and priority. These workshops engaged stakeholders through a structured participatory format that included breakout discussions, plenary sessions and guided agenda-driven dialogues. In addition, the co-creation

process provided an iterative feedback mechanism, incorporating post-workshop inputs from follow up interviews to refine research priorities. This bottom-up approach provided valuable insights into how national strategies could be adapted and tailored to specific regional contexts; explored different challenges faced and surfaced actionable research needs. covering key strategic regions selected to represent diverse geographical, agroecological regions and socio-economic contexts for smallholder farmers within the country.

A comprehensive stakeholder mapping exercise was conducted leveraging networks from the Kenya Meteorological Department (KMD) and the African Group of Negotiators Experts Support (AGNES). which ensured a wide representation that included: government agencies, local authorities, Non-Governmental Organizations (NGOs), research institutions (e.g. Universities), private sector actors, and local community representatives. Two levels of stakeholders were identified, primary and secondary. **Primary Stakeholders** included farmers and farmer groups: They are directly impacted by climate change; these stakeholders are at the forefront of implementing adaptation actions and are significantly influenced by agricultural policies and practices. **Secondary Stakeholders** included county Extension Officers that play a pivotal role in translating policies into practical applications and influencing farmer behavior and County Meteorological Officers who provide essential climate data that supports informed decision-making at the local level.

The Key findings from co-creation workshops in Kenya highlighted critical adaptation gaps hindering smallholder farmers' resilience to climate change, categorized into Financial constraints, technological barriers, information dissemination challenges, and poor stakeholder coordination. **Financial and technological** adaptation gaps are deeply intertwined challenges that significantly hinder smallholder farmers' ability to adapt to climate change. Across the regions, high cost of adaptation technologies limits their uptake, particularly in resource-constrained areas like the ASALs and the Coastal Lowlands. Many smallholder farmers find these technologies unaffordable, a challenge further exacerbated by limited access to insurance services, which are some safeguards to reduce vulnerability against climate-related shocks. This financial barrier prevents farmers from investing in technologies that could help them adapt to the impacts of climate risks and hazards, leaving them vulnerable to the impacts of climate change. While finance was cited as the main gap in the uptake of adaptation technologies for smallholder farmers, limited exposure to and knowledge of available technologies was also noted as a key gap leading low adoption of technology across the regions. Smallholder farmers often lack the resources or awareness to adopt innovative practices. Furthermore, lack of sustainability in short-term/pilot adaptation projects, particularly in the Western Highlands and Rift Valley, has created a dependency syndrome among smallholder farmers. When projects end, the smallholder farmers are left without the resources or knowledge to continue the adaptation practices, undermining long-term resilience.

Information dissemination also emerged as a critical adaptation gap across all the regions. Smallholder farmers frequently lack access to timely and accurate information on weather forecasting, adaptation technologies, and best practices. Illiteracy, particularly in the ASALs, further limits the effectiveness of information dissemination efforts. The reduction in extension services as observed in all the regions has left many smallholder farmers without the support they need, especially on technical advice and necessary inputs they need in boosting agricultural production. In the Western Highlands and Rift Valley, communication gaps between researchers, practitioners, and farmers have resulted in poor dissemination of innovations. Additionally, the disconnect

between scientific research and traditional/local/indigenous knowledge has restricted the development and dissemination of locally relevant solutions, further widening the information gap. Smallholder farmers emphasized the need for simpler, more relevant communication strategies that break down complex information into actionable steps to enhance their adaptation against climate shocks.

Stakeholder coordination is another significant adaptation gap that was observed. Poor collaboration among stakeholders, including government agencies, researchers, donors, and the smallholder farmers, has led to duplication of efforts and misguided research priorities. In the ASALs and along the Coast, for instance, inadequate support from the government and poor coordination among stakeholders have hindered the implementation of effective adaptation strategies in the agriculture sector. Similarly, in the Western Highlands and Rift Valley, it was observed that project implementation often lacks equity, inclusivity, and proper representativeness, further marginalizing vulnerable groups. The lack of adequate frameworks to monitor and evaluate adaptation projects further limits their effectiveness, as there is no systematic way to learn from successes and failures. This calls for the need to develop stronger institutional frameworks, platforms for knowledge sharing, and inclusive planning processes that would enhance stakeholder coordination in addressing the impact of climate change, particularly among the vulnerable communities.

The Key action-oriented research priorities also formed the key findings which are based on the three agriculture sub-sector including Crop, Livestock and Fisheries subsectors. For the **crop sub-sector, the priority research area** include: Emerging pests and diseases, such as Fall Army Worm, locusts, and fungal infections, require environmentally friendly control methods to safeguard human and environmental health while boosting yields; Value addition techniques are needed to reduce post-harvest losses, improve market access, and increase farmer incomes through scalable, locally available solutions; Developing drought-tolerant crop varieties and cost-effective modern farming methods, particularly moisture conservation strategies, is essential to improve resilience in low-rainfall areas; Reclassifying agroclimatic zones to reflect current climate realities will enable better crop selection; and local methods for enhancing soil health, including organic and safe inorganic approaches, are crucial to combat declining fertility and acidity issues. These priorities aim to create sustainable, productive agricultural systems that benefit smallholder farmers.

The **priority research area in the livestock subsector** include: Augmenting animal nutrition aims to tackle feed shortages and degraded rangelands by developing drought-tolerant feeds and alternative feed sources, ensuring better livestock nutrition; Protecting animal health involves breeding livestock resilient to heat stress and diseases, alongside researching organic treatments and scalable local health interventions to enhance productivity and reduce disease susceptibility; Water conservation efforts target sustainable solutions like water pans, dams, and irrigation systems, particularly for water-scarce ASAL regions; and New breed and breeding best practices aim to improve livestock productivity and climate resilience by crossbreeding indigenous and exotic breeds, creating hardy and productive livestock suited to changing environmental conditions. These research areas collectively aim to build sustainable and resilient livestock systems.

The **fish sub-sector priority action research areas** include: Sustainable feeds for aquaculture aim to reduce dependence on costly commercial fish feeds by developing locally available, affordable alternatives; Best management practices, such as pond protection, optimal fingerling raising, and region-specific species selection, are expected to improve survival rates and overall efficiency;

Emerging technologies in culture systems, breeding, fish health, and value addition seek to boost productivity and reduce production costs; and Fast-growing fish species, improving breeding techniques, and implementing biological population controls address challenges like overbreeding, slow growth rates, and high costs, ensuring more efficient and sustainable aquaculture systems. These efforts collectively aim to support smallholder farmers and enhance the resilience of fish farming.

In conclusion, this report highlights the urgent need for context-specific adaptation strategies to address Kenya's climate challenges. Collaborative, inclusive approaches like co-creation workshops are essential for tailoring interventions to smallholder farmers' unique circumstances. Enhanced research, investment, and knowledge-sharing mechanisms will support sustainable agricultural development and climate resilience.

CHAPTER 1: INTRODUCTION

Kenya's climate is highly variable both in time and space just like the rest of East Africa and other parts of the tropics and as such it is prone to climate extremes such as but not limited to floods, landslides, and droughts. In the last decade alone, the frequency and severity of climate extremes have become increasingly evident as the climate continues to warm (KMD, 2024). Virtually all sectors of the Kenyan economy are dependent to some extent on weather. Agriculture is one of the most economically significant contributors to the Kenyan economy, directly contributing 26% of the GDP annually, and another 25% indirectly to its economy. The sector accounts for 65% of Kenya's total exports and provides over 70% of informal employment. Agriculture is practised at both subsistence and commercial scale in Kenya, mainly in rural areas but increasingly in urban areas. Hence, the agricultural sector is not only the driver of Kenya's economy but as a means of livelihood for the teeming Kenyan population.

There are three main sub-sectors of the agricultural sector in Kenya, namely crop, livestock and fisheries. These are practised at varying scales in different climatological zones in the country as appropriate. The agricultural sector is largely rainfed with two main rainfall seasons per year: March to May, and October to December and in some parts during the additional rainfall season June to August. This makes the sector vulnerable to changing weather patterns due to climate change. Alongside changing weather patterns, the sector faces challenges from crop pests and diseases, weeds, labour constraints, and the rising cost of farm inputs to some extent also impacted by climate change (Nying'uro *et al* 2024). These challenges increasingly create the need for urgent adaptation measures to secure lives and strengthen livelihoods. Agricultural adaptation is rapidly being recognized as an immediate global need, especially in developing countries with lower resilience and higher vulnerability. Kenya heavily depends on rainfed agriculture for livelihood and food security particularly among smallholder farmers, robust locally-driven adaptation measures are thus crucial in safeguarding lives and livelihoods as climate change continues to exacerbate new risks of loss and damage. The IPCC WGII report alarmingly highlights that adaptation progress in many developing countries including Kenya is fragmented, incremental, not scalable and largely ineffective (IPCC, 2022). This then raises the question of what is the best way to design adaptation approaches that are effective and sustainable.

Increasingly co-creation has been hailed as an effective alternative to traditional adaptation planning which is a typically top-down approach. Several studies, including one by Van der Host *et al* (2022) have shown that a bottom-up approach is more useful in capturing local context for effective adaptation planning. In their 20202 paper, Vedeld *et al* researched 4 methods of engagement and interaction in developing services for smallholder farmers. The most successful method was the co-creation of the service. To support smallholder farmers' adaptation and risk decision-making in the face of climate change, knowledge needs to be targeted and tailored to specific local circumstances.

The Adaptation Research Alliance (ARA) is guided by six principles that place local needs and co-creation at its centre. Key among these principles are;

1. Research is demand-driven, and solutions-oriented - the needs of users are what drive research and this research seeks to find practical and implementable solutions for addressing climate risks.
2. Research is transdisciplinary and co-produced through a collaborative effort with users.
3. Research processes address structural inequalities faced by women, youth, children, disabled and displaced people, Indigenous Peoples and marginalized ethnic groups.

With these in mind the "Accelerating Smallholder Agriculture Adaptation Co-design Project" sought to co-create research areas in adaptation by engaging local communities of smallholder farmers across the country. The main aim of the co-creation of the research areas was to address the actual needs of the smallholder farmers in terms of what additional information they need to adequately adapt to climate change and its impacts on their agricultural activities. Chapter 3 highlights the methodological approach for carrying out the co-creation including the different regions selected and their short descriptions which are further expounded on in Chapter 2.

The project's spatial scope was Kenya which is already facing the impacts of climate change on the agricultural sector in the form of severe frequent droughts interspersed by flooding. Agro-climatologically, Kenya is divided into 7 zones (Fig 1a) Different crops are grown in different areas based on the moisture, temperature and rainfall profiles and different livestock are kept in various zones (Fig 1b). Crops grown and livestock produced in these regions are impacted in varied ways by changing climate therefore adaptation responses likewise vary influenced too by additional factors such as land tenure systems, economic status, and social and cultural values among others.

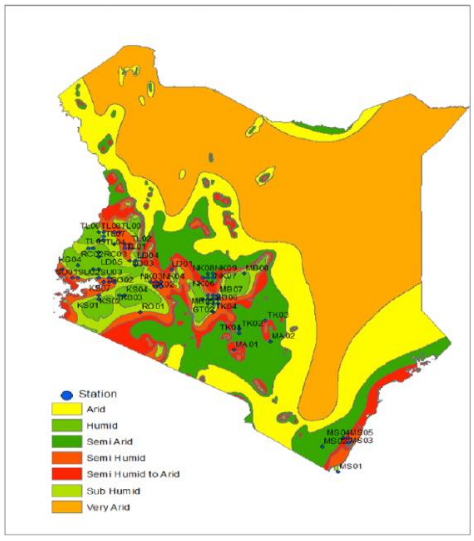

Figure 1(a): *Kenya Agro-ecological Zones*
Source: Agcenture

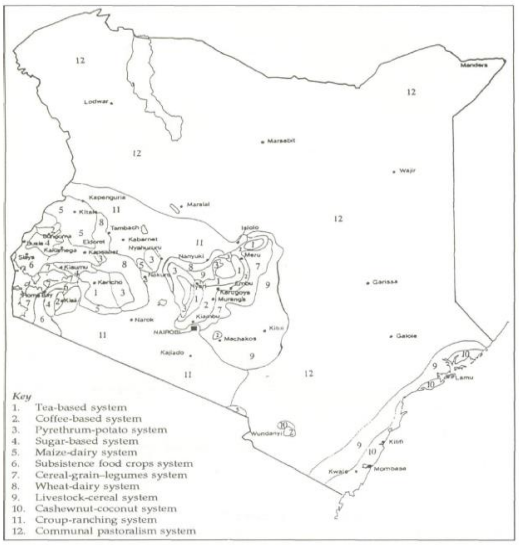

Figure 1(b): *Major land-use systems in Kenya*
Source: World Agroforestry Centre

Additionally, 80% of the country is characterized as arid semi-arid lands (ASAL) based on the relatively low amounts of rainfall received on an annual and seasonal timescale (Fig 2). Agricultural production in ASAL regions is heavily reliant on rain-fed smallholder subsistence farming, which exposes the sector to profound impacts of climate variability and change. Climate change has

exacerbated existing vulnerabilities and risks plunging communities in the region into lower agricultural productivity, induced mobility, resource-based conflicts, limited access to markets, inadequate veterinary services and absolute poverty. Pastoralism is the predominant livelihood in ASAL counties, with communities depending largely on livestock production for their sustenance and economic activities. Key statistics highlight the significance of pastoral systems: ASAL regions host over 70% of Kenya's livestock, including cattle, sheep, goats, and camels. Livestock production contributes approximately 10% to the national GDP and about 50% to the agricultural GDP. Pastoralism employs around 90% of the population in ASAL counties, indicating its central role in livelihoods and local economies.

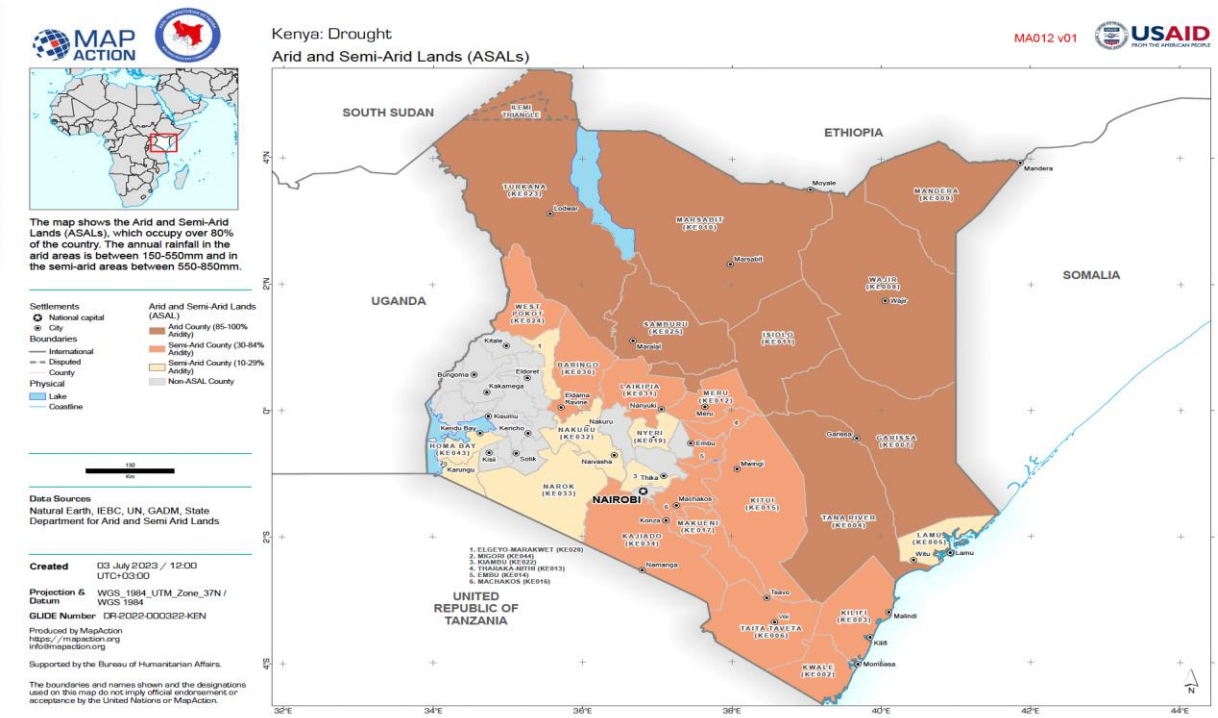

Figure 2: *Showing Kenya's ASAL regions; dark brown showing Arid counties (85-100% aridity, light brown Semi-Arid regions (30-84% aridity), yellow Semi-Arid regions (20-29% aridity).*
Source: Relief Web

In the rest of the land types crop farming, livestock keeping and fisheries are usually combined by smallholder farmers. Highland regions have two main growing seasons following the rainfall seasons and plant a variety of crops to take advantage of the rainfall in those seasons. Increasingly under climate change, the suitability ranges of crops are changing as are the thresholds for pests and diseases negatively impacting crops, livestock and fisheries. Lawrence *et al* (2023) showed that between 1980 and 2020 climate-suitable areas for primary crops increased 3% in highly productive counties, decreased 25% in moderately productive counties, and decreased 62% in low productive counties. For ranching areas, suitability decreased by 13%, 21% for dairying areas, 24% for mixed crop and ranching areas, and 28% for mixed crop and dairying areas, while for pastoralism increased by 12%.

In Mombasa, the primary economic activities are tourism, trade, and fishing, with agriculture employing around 20% of the population. Kwale and Kilifi focus on both subsistence and commercial agriculture, including sugarcane, cassava, and coconut farming, employing about 60% and 70% of the population, respectively. Tana River supports significant pastoralism and crop farming, with agriculture employing around 75% of the population. Lamu relies heavily on fishing and agri-value chains like mangoes and coconuts, with agriculture employing 65% of the population. In the South-Eastern lowlands region, Machakos is a key agricultural hub, focusing on fruits, vegetables, and dairy farming, employing approximately 80% of the population. Makueni specializes in mango and citrus farming, with agriculture employing about 85% of the labour force. Taita Taveta is known for its horticulture, livestock farming, and sisal plantations, employing around 70% of the local labour force. Kajiado is primarily pastoral, with significant activities in livestock farming, employing around 60% of the population. Kitui is known for its cotton and mango production, with agriculture employing 75% of the local labour force. These counties receive varying amounts of rainfall, supporting diverse agricultural activities. However, high rainfall variability and climate extremes have posed significant challenges to rainfed agriculture including disrupting crop growth, reducing yields, and diminishing water levels in rivers, affecting irrigation and drinking water quantity and quality. These challenges necessitate the adoption of cost-effective climate change adaptation strategies to increase resilience and sustain livelihoods.

This climate variability and change coupled with an increase in population in Kenya calls for context-specific solutions to cope with the changes and more so from a local smallholder farmer perspective. The Accelerating Action Research for Smallholder Agriculture Adaptation Project commenced in April 2024 and is set to conclude in December 2024 with a project report clearly highlighting the process and the key outcomes being priority research areas for funding.

CHAPTER 2: KENYA CLIMATE RISKS & ADAPTATION POLICY LANDSCAPE

This chapter provides an overview of climate risks facing Kenya's agricultural sector particularly the regions selected to host the subnational co-creation workshops, as well as the adaptation policy landscape within the agricultural sector. It examines the historic, current and projected climate risks, identifies adaptation needs and gaps, outlines the geographical and socioeconomic context, and reviews the relevant policy frameworks guiding climate resilience in agriculture.

2.1 Climate Risks facing Kenya's Agricultural Sector

Kenya faces a range of climate risks that significantly impact its agricultural sector. With agriculture as a mainstay of the economy, supporting directly and indirectly over 75% of the population, climate change poses direct threats to food security, livelihood security, and economic stability. Increasingly erratic rainfall, rising temperatures, and frequent extreme events including droughts and floods have heightened the vulnerability of Kenya's agricultural systems. The following statistics highlight the key climate risks:

1. Rainfall patterns

Kenya has witnessed fluctuations in annual rainfall, with significant deviations from average seasonal rainfall. Kenya has witnessed a 10-15% deviation in average annual rainfall, disrupting planting and harvesting cycles. Flash floods (Kimutai et al., 2022) and delays in the onset of the long rains (March-May rainfall) and short rains (October-December rainfall) have led to insufficient water availability during critical growing periods. For instance, rainfall in 2019 was unusually high, causing widespread flooding, particularly in Western Kenya and Coastal regions, which led to crop losses and infrastructure damage (Wainwright et al., 2019). By contrast, rainfall in 2022 was well below average, exacerbating drought conditions in arid and semi-arid (ASAL) regions. Prolonged droughts are a recurring issue, the frequency and severity of droughts have increased with 2020–2022 marking one of the worst drought periods in the last decade. Northern and Eastern Counties such as Turkana, Mandera, Wajir, Garissa Tana River, West Pokot and Marsabit were particularly hard-hit, with deaths reported and over 1.5 million livestock lost and widespread crop failures, affecting the livelihoods of millions dependent on pastoralism.

Flooding in the country has become a recurring challenge, with climate change and erratic rainfall patterns intensifying its frequency and severity. Historically, floods in Kenya occur primarily during the "long rains" season from March to May and the "short rains" from October to December. Over the past five years (2018–2022), severe floods have affected over 300,000 people on average each year, particularly in low-lying and riverine areas where vulnerability to water surges is high (Kimutai et al., 2022; WWA; Kimutai et al., 2023). The impacts of these floods extend beyond displacement, affecting agriculture, infrastructure, and essential public services.

2. Temperature

Average temperatures have risen steadily, with annual increases between 0.2°C and 0.4°C since 2018, increasing heat stress on crops and livestock and affecting water availability for agriculture. The ASAL regions are especially vulnerable, as increased temperatures compound water scarcity, pasture availability and land degradation. Rising temperatures have resulted in more frequent heat waves in different regions of the country, which will increase heat-related mortality for both the human and Livestock populations. The percentage of Kenya's population affected by at least one heatwave per year is projected to increase significantly, rising from 0.6% in 2000 to 6.0% by 2080 (Nying'uro et al ., 2024; GIZ, 2021). Extreme heatwave events have also led to crop failure, notably for staple crops like maize and beans. The most affected areas are the eastern parts of the country, especially Garissa and Tana River counties, and in the west-northern side around the upper side of Turkana County. In recent years' heatwaves compounding with droughts have been more severe in magnitude over the Horn of Africa (IPCC, 2021).

2.3 Description of the Climate and Geography of Selected Regions

Understanding Kenya's climate, geographical and socio-cultural diversity is crucial for the co-creation of effective climate adaptation strategies for smallholder agriculture. Co-creation workshops were held in four (4) distinct zone profiles: ***Coastal Plains and Lowlands; Central Highlands; Western Highlands; and some selected Arid and Semi-Arid Lands (ASALs).*** Based on these classifications, counties were grouped.

2.3.1 Coastal Plains and Lowlands

Kenya's Coastal Plains and Lowlands experience a tropical climate marked by high humidity and rainfall, creating an environment conducive to agriculture and fishing. These regions encompass the counties of Mombasa, Kwale, Kilifi, Tana River, Lamu, and Taita Taveta. This region supports diverse livelihood activities, including fishing and crop production. However, climate risks such as flooding, saltwater intrusion, and rising sea levels in coastal areas pose significant challenges to soil and water quality, threatening agricultural productivity and community resilience.

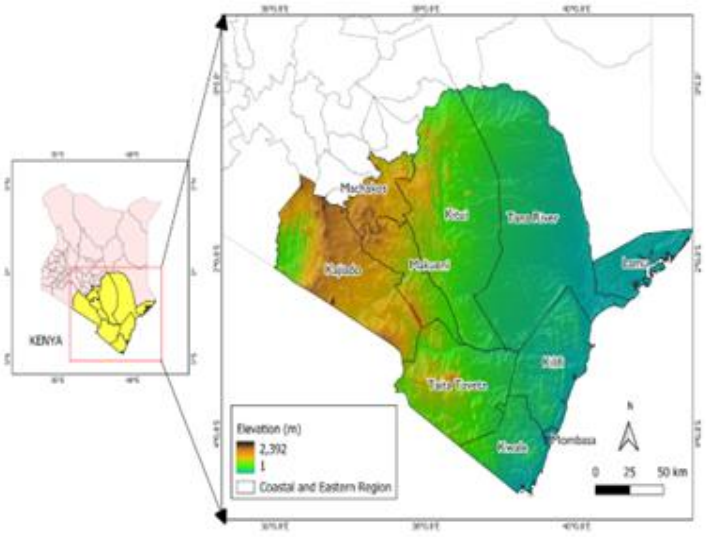

Figure 3. *Showing counties encompassing the coastal and South East lowlands of Kenya*

2.3.2. Central Highlands

Kenya's Central Highlands, recognized as a key food basket region, holds immense potential for bolstering national food and agricultural production. The region enjoys favourable annual rainfall ranging from 450mm in drier areas to 1400mm in higher elevations, enabling a variety of agricultural activities such as crop cultivation, livestock rearing, and fish farming. Spanning nine counties—Kiambu, Kirinyaga, Murang'a, Nyandarua, Nakuru, Embu, Tharaka Nithi, Nyeri, and Meru—agriculture is the cornerstone of the local economy. It employs over 50% of the workforce and accounts for approximately 40% of household income.

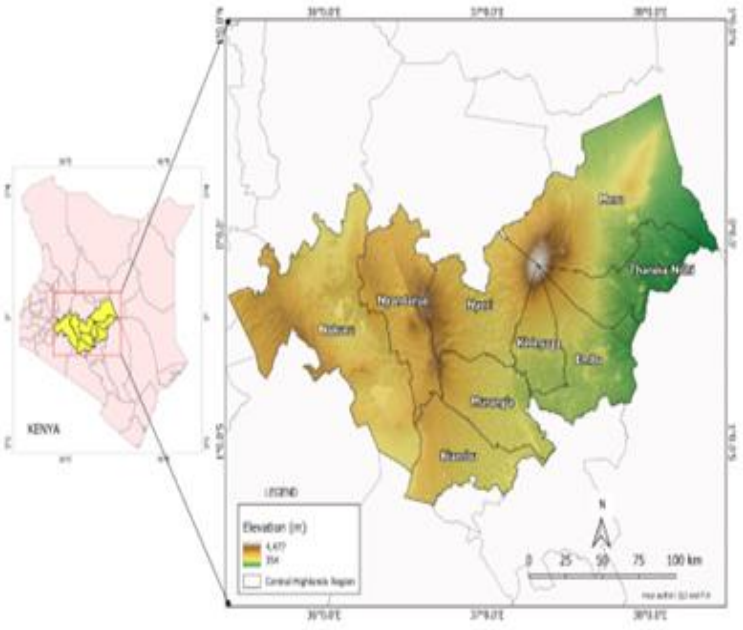

Figure 4*. Showing counties encompassing the central highlands of Kenya*

2.3.3 Western Highlands

Kenya's Western Highlands, another vital food basket region, benefit from abundant rainfall and fertile soils, which support intensive agricultural production. The region is renowned for its high yields in cash crops such as tea, maize, horticultural produce, and cereals, significantly contributing to the country's economy. However, the sustainability of smallholder farming in this area is under threat due to challenges like unpredictable rainfall patterns, soil degradation, and declining soil fertility, all of which adversely affect productivity. The region comprises counties such as Trans Nzoia, Turkana, Vihiga, Elgeyo Marakwet, Kisumu, Siaya, Uasin Gishu, Kakamega, Kisii, Homa Bay, and Kericho.

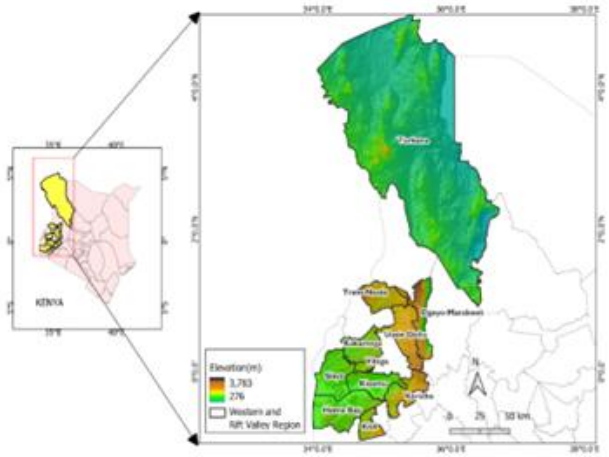

Figure 5. Showing counties encompassing the western highlands of Kenya

2.3.4 Arid and Semi-Arid Lands (ASALs)

The ASALs region spans 23 counties in Kenya: Baringo, Garissa, Isiolo, Mandera, Marsabit, Samburu, Tana River, Turkana, Wajir, Embu, Kajiado, Kilifi, Kitui, Kwale, Laikipia, Lamu, Makueni, Narok, Nyeri, Taita Taveta, Tharaka Nithi, and West Pokot. While pastoralism remains the primary livelihood in these counties, there is a growing trend toward livelihood diversification, with many communities shifting to agro-pastoralism and crop farming. Crop production remains limited, focusing mainly on drought-resistant varieties such as millet and sorghum.

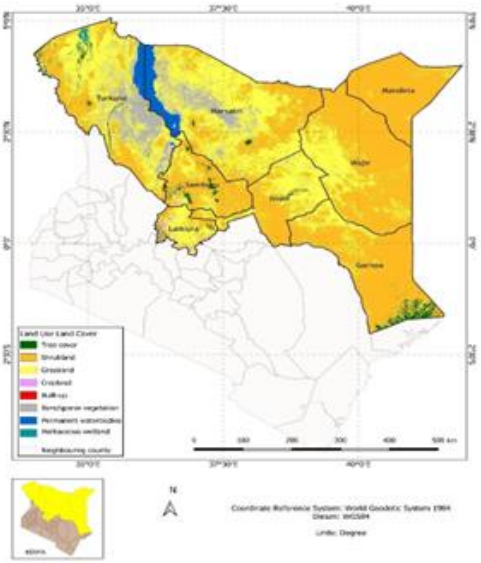

Figure 6. Showing counties encompassing ASAL regions of Kenya

2.4. Overview of Adaptation Policy Landscape

2.4.1.Global Perspective

The United Nations Framework Convention for Climate Change (UNFCCC) process through the Paris Agreement (Article 7) established the Global Goal on Adaptation (GGA) on enhancing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change and associated impacts. While the Intergovernmental Panel on Climate Change (IPCC) acknowledges that progress in adaptation has been observed across all regions generating multiple benefits (IPCC, 2022), it remains uneven, fragmented, incremental and lagging in all areas (finance, planning and implementation; UNEP, 2023). Progress in climate adaptation is reported to be lagging and slowing, with the finance gap for these initiatives exceeding previous estimates by at least 50%, with more focus placed on mitigation.

Developing countries are grappling with substantial adaptation costs, projected at $215 billion annually for the current decade. To meet these demands, domestic adaptation financing needs to reach $387 billion annually, or about $1,200 per person in the U.S. Despite this, public multilateral and bilateral adaptation finance to these nations dropped by 15% in 2021, falling to $21 billion, or roughly $65 per person in the U.S. (AoN, 2023). This decline, combined with rising adaptation demands, has created a significant adaptation finance gap, pushing countries deeper into debt as they address climate disasters.

2.4.2. Regional/Continental Perspective

In Africa, substantial gaps remain in the means of implementation needed to scale these adaptation efforts. Many African nations face barriers in accessing climate finance due to complex application processes and limited technical capacity, which leaves projects underfunded and delays critical adaptation efforts. Effective and transformative adaptation requires significant financial support, both for short-medium term needs (e.g., resilient food production systems) and long-term investments in infrastructure, such as resilient water systems, roads, and healthcare facilities.

In an effort to address these gaps, the African Union's (AU) **Climate Change and Resilient Development Strategy (2022–2032)** emphasizes the need for global collaboration to mobilize climate finance, build local capacity, and support technology transfer for adoption and adaptation across the continent. The AU calls for adaptation funding as a global responsibility, especially from high-emission countries, to support low-emission, high-impact regions like Africa. This mission is further supported by Regional Economic Communities such as EAC, IGAD, COMESA and others which work to coordinate adaptation efforts and facilitate resource-sharing across borders, enhancing resilience in vulnerable areas. The Great Green Wall is one such continental initiative coordinated at both sub-regional and national scales spanning from the Sahel to the Horn of Africa. The wall focuses on afforestation, soil restoration, and ecosystem rehabilitation to combat desertification, improve land productivity, and relieve pressure on natural resources. Fostering

transboundary and regional collaboration is key in addressing the cross-border nature of climate risks.

2.4.3 National Landscape

Kenya's adaptation landscape is shaped by its diverse ecosystems, ranging from ASALs to lowland and highland regions with distinct agricultural and water resource adaptation needs, gaps and challenges. Given its vulnerability to the various climate extremes, Kenya's national adaptation needs are mainly centred on the implementation of climate-smart agriculture (CSA), enhancing drought resilience, improving water management and investment, and diversifying livelihood sources. While Kenya has developed adaptation plans, strategies and frameworks, substantial gaps remain in financing, technological access, and localized research. These gaps hinder the scale and effectiveness of adaptation efforts, highlighting the need for targeted investments and regional partnerships to address Kenya's diverse climate challenges effectively.

2.4.4 Sub-national (County) Landscape

At the sub-national level, Kenya's adaptation needs vary significantly according to regional climate and geographic contexts within each county. In ASAL counties, adaptation strategies focus on rangeland management, drought-resistant agricultural practices, livestock management, and soil and water conservation to combat water scarcity and land degradation. Conversely, the Western Highlands face issues related to intense rainfall and flush flooding, making flood-resilient infrastructure and agricultural practices a priority. Coastal areas, threatened by rising sea levels and saltwater intrusion, require specialized approaches to protect both natural ecosystems, mangrove protection and local economies.

2.5. Policy Landscape: Climate Adaptation Policies in Kenya's Agriculture Sector

Kenya's agricultural sector is at the forefront of climate adaptation efforts, driven by robust policy frameworks that have been developed and some ratified based on international and regional agreements to which it is a signatory. **The Climate Change Act (2023**) is Kenya's foundational legislation for coordinating national responses to climate change. The Act establishes institutional frameworks for climate governance, sets out mechanisms for climate action planning, and mandates the integration of climate considerations into all sectors. **National Adaptation Plan (NAP) 2015-2030** outlines Kenya's strategy for adapting to climate change impacts across various sectors, with agriculture being a critical focus area. The plan identifies priority adaptation areas, sets targets for resilience building, and allocates resources for implementation. It emphasizes the importance of stakeholder collaboration, capacity building, and the use of scientific research to inform adaptation strategies. **National Climate Change Action Plan (NCCAP III) 2023-2027** provides a detailed roadmap for climate action, focusing on both mitigation and adaptation. For the agricultural sector, the plan promotes climate-resilient farming practices, efficient water management, and the development of early warning systems for extreme weather events.

Agriculture Sector Transformation and Growth Strategy (ASTGS) 2019-2029 aims to transform Kenya's agricultural sector into a productive, competitive, and climate-resilient industry. It emphasizes the adoption of climate-smart technologies, enhancement of value chains, and improvement of market access and economic growth. The **Kenya Climate Smart Agriculture Strategy (KCSAS) 2017-2026 and KSCA implementation Framework 2018-2027** aim to mainstream climate-smart practices and promote the adoption of resilient crops and crop varieties, efficient irrigation systems, and sustainable land management practices. The **Kenya National Soil Management Policy (2023)** focuses on conserving and enhancing soil health to support sustainable agriculture. The policy also emphasizes the importance of research and innovation in developing soil management techniques that enhance agricultural resilience to climate change. The **Kenya Agricultural and Livestock Research Act No. 17 of 2013** establishes the legal framework for advancing agricultural and livestock research in Kenya, emphasizing the development of resilient agricultural systems. The Act promotes collaboration between research institutions, farmers, and the private sector to facilitate the adoption of research-based solutions for climate resilience.

County Policy landscape

At the sub-national level, all counties are required to develop County Integrated Development Plans (CIDPs) which outline their 5-year development plans for and include climate action ambitions for both adaptation and mitigation. These CIDPs are linked to national-level policies. The National Climate Change Action Plan is the main adaptation planning instrument that counties draw from for local-level adaptation planning. The CIDPs are expected to capture local context challenges, risks and lived realities of the diverse counties in the country. CIDPs work to mainstream climate resilience across the different priority sectors and into development actions making climate change a key pillar towards achieving development goals as described in Kenya's Vision 2030. Additional policy instruments include the **County Climate Change Acts or Policies**; almost all counties have developed these policies which form the legal frameworks for guiding context-specific localized county climate actions in response to the local impacts of climate change. The act establishes the operative structure right from the lowest administrative block (wards) right to the county level (taking a bottom-up approach).

CHAPTER 3: METHODOLOGICAL APPROACH TO CO-CREATION

This chapter outlines the methodology employed in the co-creation process to identify and prioritize action-research areas and scalable, locally-led adaptation strategies for smallholder farmers across various agroecological zones. It describes the design of workshops held at national and sub-national levels, the approaches used to engage a wide range of stakeholders, and the techniques applied to prioritize actionable research areas. Additionally, the chapter highlights the integration of gender equality and social inclusion (GESI) considerations to ensure a balanced representation of diverse perspectives, along with the feedback mechanisms utilized to evaluate stakeholder satisfaction.

3.1. Co-Creation Approach

An initial review and scoping paper synthesizing outcomes and learning from past projects and programmes and identifying relevant agriculture and climate research and action actors, which also provided as a reference and resources for the workshops was conducted by the African Research and Impact Network (ARIN). A total of six (6) co-creation workshops were conducted: two at the national level and four at the sub-national level, covering key strategic regions selected to represent diverse geographical, agroecological regions and socio-economic contexts for smallholder farmers within the country. The sub-national workshops were organized by regional selection, with groupings by counties to ensure that local perspectives and priorities were captured and included in the discussions. Figure 7 illustrates the step-by-step process of co-creation, beginning with the scoping phase to identify key challenges and opportunities, followed by stakeholder engagement, participatory workshops and iterative feedback. The workflow culminates in the generation of actionable research priorities, ensuring alignment with local needs and inclusivity in decision-making. Each stage integrates mechanisms for collaboration, gender equality, and social inclusion, ensuring that the final outputs are both practical and equitable.

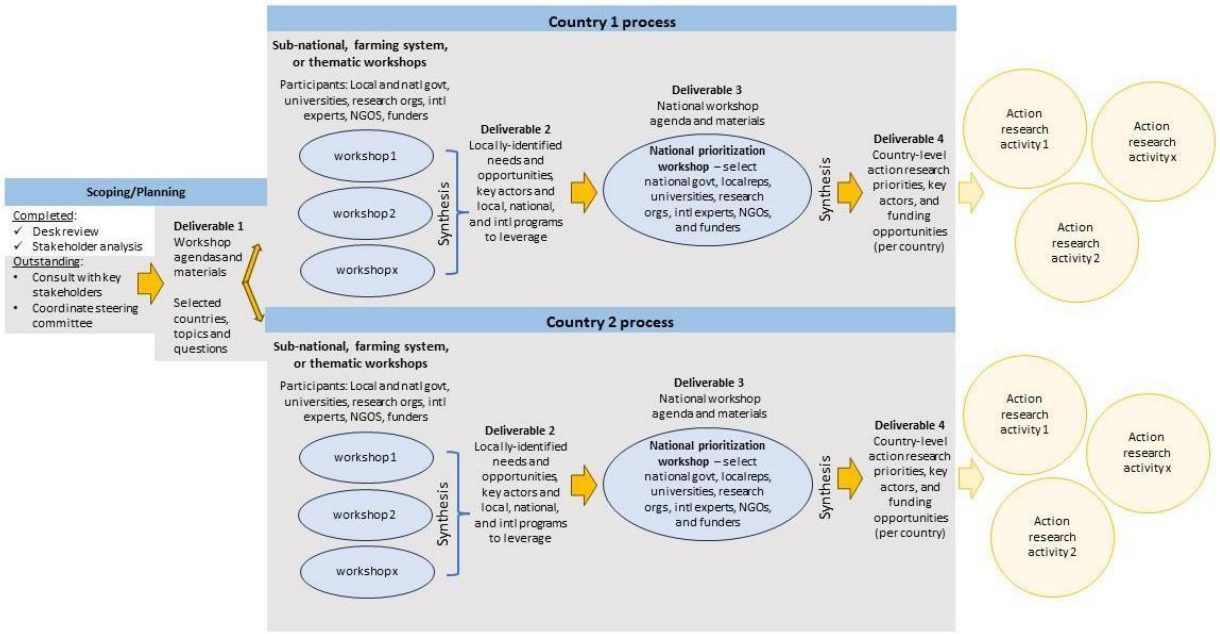

Figure 7. *Showing the co-creation workflow — from the scoping to the generation of actionable research priorities*

3.1.1. National level workshops

These sessions brought together stakeholders working at the national level, for various sectors, government agencies, and organizations to provide a comprehensive overview of national climate priorities and adaptation needs for smallholder farmers. The national workshops aimed to set the stage for a coordinated and inclusive engagement approach allowing feedback loops from sub-national workshops.

3.1.2 Subnational workshops

Four regional workshops were held to capture the unique needs and challenges of smallholder farming in different areas within the country. By grouping counties within specific regions, the co-creation approach ensured that localized smallholder agriculture issues and priorities were highlighted. Different stakeholders engaged in a workshop format characterised by breakout groups, plenary sessions guided by a set of questions and agenda points and post-workshop feedback iterations. This bottom-up approach provided valuable insights into how national strategies could be adapted and tailored to specific regional contexts; explored different challenges faced and surfaced actionable research needs.

3.2 Stakeholder Mapping

An essential part of the co-creation process was the identification and initial engagement of key and relevant stakeholders in the smallholder agriculture sector through stakeholder mapping. The two levels of identified stakeholders are:

- **Primary stakeholders**: *Farmers and Farmer Groups* who are directly impacted by Climate Change; are affected by agricultural policies and practices; and are crucial for the implementation of adaptation actions.
- **Secondary stakeholders**: *County Extension Officers* are key in translating policies into practice and influencing farmer behaviour. *County Meteorological Officers* provide crucial climate data influencing decision-making.

The stakeholder mapping also leveraged on Kenya Meteorological Department (KMD) and AGNES networks, which ensured a wide representation that included: government agencies, local authorities, Non-Governmental Organisations (NGOs), research institutions (e.g. Universities), private sector actors, and local community representatives. Communication for initial engagement and invitations to workshops was primarily through emails mobile calls and text messages. The total number of participants across all workshops reached approximately two hundred, with representation from different levels of decision-making ensuring a diverse set of perspectives and expertise. We show the composition of stakeholders in Figure 8 which outlines a breakdown of the diverse stakeholder groups involved in the co-creation workshop.

3.3 Mode of Interaction: Co-creation process

To foster a collaborative and interactive environment, multiple modes of engagement were employed throughout the workshops:

(i) Breakout Groups: Participants were divided into smaller breakout groups based on sectors of expertise and gender. Using guiding questions (see section 3.3.1), these groups facilitated in-depth discussions on targeted topics, encouraging participants to explore and exchange ideas in a more focused setting. Breakout groups also promoted cross-sectoral learning, with representatives/stakeholders from different fields/expertise contributing varied insights.

(ii) Plenary Sessions: Each breakout group presented their findings in plenary sessions, allowing the entire workshop participants to discuss common thematic areas. Plenary sessions helped consolidate ideas from all groups, identify overlapping priorities, and clarify points of agreement and disagreement among stakeholders.

(iii) Post-Workshop Iterations: After each workshop, participants had the opportunity to review outcomes and provide additional feedback. This iterative approach ensured that ideas and priorities could be refined based on ongoing insights, enhancing the responsiveness and adaptability of the co-creation process.

3.3.1 Guiding Questions

To steer discussions effectively and gather targeted insights, a set of guiding questions was developed in consultation with ARA and BMGF. These questions were tailored to uncover gaps in current adaptation efforts, identify knowledge gaps and actionable research areas, and explore ways to enhance collaboration between research institutions, local and national actors/decision-makers and communities. They guided the discussions within breakout groups and provided a framework for systematically identifying adaptation priorities and research needs.

Workshop Guiding questions

- *What are the most significant practice and knowledge gaps in current adaptation research in the agricultural sector?*
- *How can existing adaptation efforts be scaled up or modified to better meet the needs of communities in the Coastal and Eastern counties?*
- *Is there gender-dynamic within the community that influences adaptation effort?*
- *How can research institutions and local communities collaborate more effectively to inform, develop and implement adaptation strategies?*
- *What specific actionable research areas could help address the adaptation needs of small-scale farmers in crop/livestock/fish farming in the region?*
- *What is the missing information/knowledge that could assist smallholder farmers to better adapt to climate risks across the different aspects of agriculture (livestock, crops and water/fisheries)?*

3.3.2 Gender Equality and Social Inclusion (GESI) Considerations

A critical component of the co-creation approach deployed was ensuring gender equality and social inclusion (GESI) across all activities. These include:

(i) **Breakout Group Composition:** Each breakout group was composed of diverse stakeholders to ensure diverse representation, particularly of women, youth, marginalized communities, and other vulnerable groups. This intentional composition aimed to capture a broad range of perspectives, ensuring that the voices of underrepresented groups were included in discussions and contributions in the sessions. Breakout groups were also moderated consciously to allow and encourage everyone to speak especially in communities where women and the youth seldom can speak in the presence of men.

(ii) **Addressing Gender Dynamics in Adaptation Needs**: Recognizing that gender dynamics within communities influence adaptation efforts and needs, hence GESI considerations were embedded in the co-creation discussions. This included examining how men and women experience climate impacts differently and how adaptation strategies can be tailored to account for these differences. By addressing these dynamics, the co-creation process aimed to produce more equitable and inclusive adaptation needs.

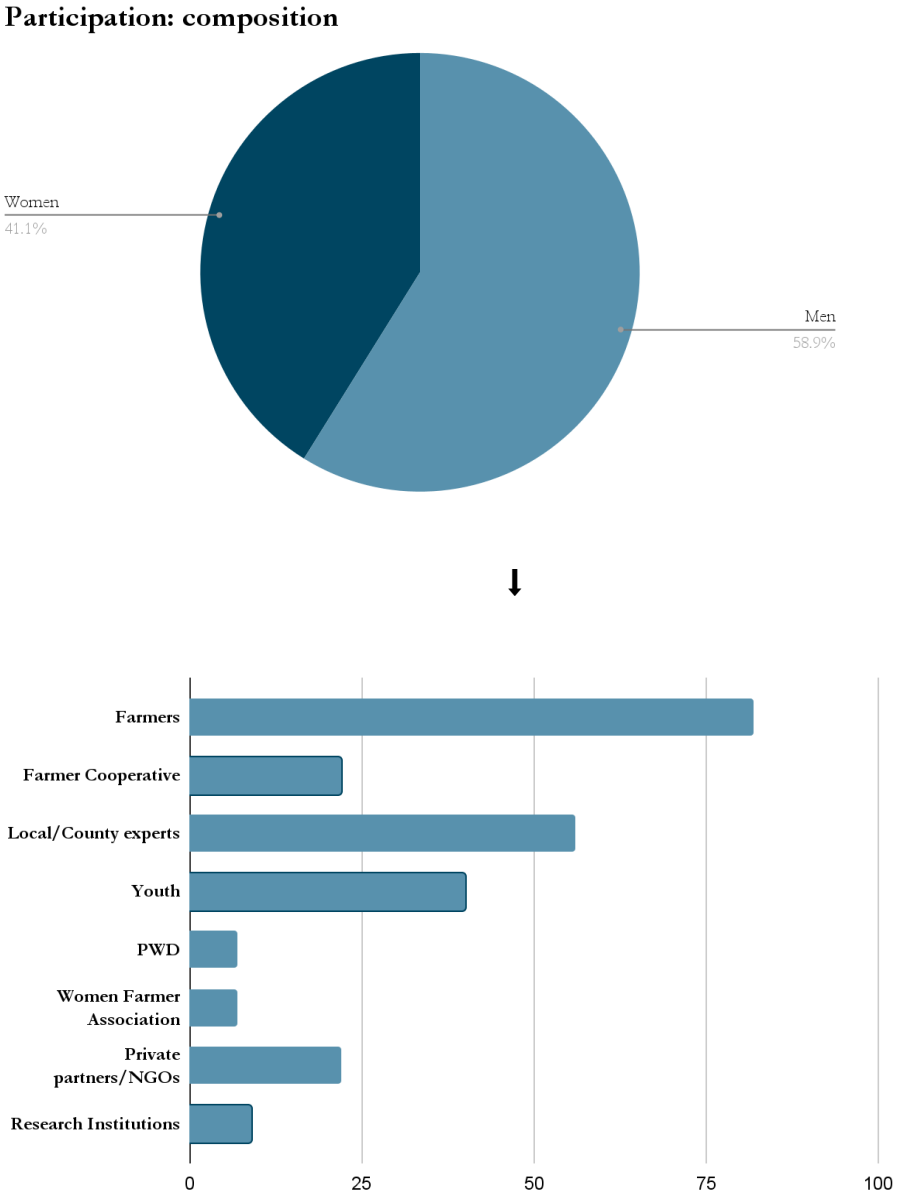

Figure 8. *Showing stakeholder composition in the Co-Creation Workshop process.*

3.4 Satisfaction Surveys

To assess the effectiveness of the workshops and gather feedback on the co-creation process, satisfaction surveys were distributed to participants after each workshop. These surveys collected data on various aspects, including:

(i) Relevance of Content: Participants were asked to rate the relevance of the workshop content to their work and interests.

(ii) Quality of Facilitation: Feedback was gathered on the quality of facilitation, including clarity, responsiveness, and ability to engage all participants.

(iii) Inclusiveness: Surveys assessed whether participants felt that the workshops were inclusive and that their perspectives were valued.

(iv) Overall Satisfaction: An overall satisfaction score provided insights into the participants' experience of the workshop. The results of the satisfaction surveys were used to refine future workshops and improve the overall co-creation process, ensuring continuous improvement and responsiveness to participant needs.

CHAPTER 4: CO-CREATION FINDINGS

This chapter focuses on the findings from the smallholder agriculture co-creation process at the sub-national and national levels in Kenya. It is divided into outcomes of both the co-creation process and findings from the workshops.

4.1 OUTCOMES: CO-CREATION PROCESS

A structured approach to prioritize action research was used to identify the most critical areas of focus for climate change adaptation in Kenya. At the national level, stakeholders participated in two (2) workshops: (a) the first workshop focused on a general outlook of smallholder agriculture in Kenya, and (b) the second workshop focused on prioritizing action research and scalable locally led adaptation strategies. The second national workshop allowed participants to evaluate and rank proposed adaptation actions based on criteria such as urgency, feasibility, and potential impact. Action research priorities were further refined by sector (e.g. crop, livestock, fisheries) to ensure that sector-specific adaptation needs were addressed. This sectoral approach recognized that different sectors face context-specific challenges and opportunities in adapting to climate change impacts. Action-oriented research agendas were also prioritized by agro-climatological zones: ASAL regions, Central highlands, Western Highlands, and the Coastal region and South East lowlands. With results from observation, comments from the participants and administered survey responses we summarize here the positive outcomes of the co-creation approach.

4.1.1 Opportunity for Cross Learning

In many of the sub-national workshops we observed, this was also mentioned by participants that there was a lot of cross-learning during their interactions at the workshops. The co-creation workshops made it possible for farmers to meet and interact, and share experiences that would otherwise not be possible and this is a key positive outcome of this co-creation process. Almost all co-creation workshop participants were impressed by the work being done by other farmers in different regions on their adaptation strategies and responses to other farming challenges. Many took these down as notes to try and implement on their farms. In one particular case in Mombasa, one woman farmer from one region talked about her successful fruit farm and how they have women groups that facilitate support among each other. The rest of the women in the breakout group expressed interest in visiting the farm for some sort of a learning trip and the woman farmer was happy to host the women. At the same workshop in Mombasa, the women all formed a WhatsApp group to share ideas, we see this as a positive outcome of the process. This platform will continue to be central for the sharing and exchange of ideas and innovations amongst the farmers themselves of different agro-climatological areas in Kenya.

4.1.2. Stakeholder Networking

The sub-national workshops provided a space for networking and exposure to varied ways of coping with climate change impacts in the agricultural sector. Evidently, some farmers utilized weather information for their decision-making while some did not. At these workshops, farmers were able to meet interact and create connections with the County Directors of Meteorology

(CDMs) who were responsible for the development and dissemination of critical weather information at seasonal, monthly, weekly and daily timescale for planning. Likewise, country agricultural officers were present as were some extension officers and the farmers were also able to link up for future support.

4.1.3. Anecdotes

Here we share some anecdotes from the process:

- **Empowering Women in Isiolo**: Women participating in the sub-national workshop in Isiolo expressed appreciation for the opportunity to gather separately, which encouraged them to speak more openly. Many noted it was their first experience in such a setting, and they gained the most from the gatherings at the co-creation workshops. In these counties, cultural norms often prevent women from voicing their opinions in the presence of men, especially in groups discussing development initiatives.
- **Social Media Adoption Among Farmers:** Farmers from the sub-national workshop in Isiolo have embraced social media to showcase their climate-smart agriculture activities and to reach a wider market for their produce — an initiative unique to this region among all workshops.
- **Climate Science Education in Nyeri:** Participants in the Nyeri co-creation workshop were captivated by the knowledge and information on the science of climate change, including its causes, as explained by one of the facilitators. This indicated some knowledge gaps that require some attention especially when dealing with smallholder agriculture farmers.
- **Knowledge in Kitale:** The workshop in Kitale revealed a rich repository of local knowledge deeply rooted in cultural and spiritual practices. Among these were the use of indigenous weather forecasting methods and traditional harvest preservation techniques. For instance, traditional forecasters from specific tribes and communities practised weather prediction by slaughtering a goat, examining its intestines, and interpreting weather patterns for the upcoming season. Others relied on observing the behaviours of plants, birds, and insects as natural indicators of impending weather changes. The goat-based rituals were considered sacred, with only ordained elders and their families possessing the "divine" authority to make such predictions. In chick brooding, women demonstrated an innovative method called "*Chepkube*," a locally developed technology for keeping chicks warm at night, providing a cost-effective alternative to modern, expensive technologies.

4.2. OUTCOMES: WORKSHOP FINDINGS

4.2.1 National Baseline Workshop

The national baseline workshop was the first in this series of co-creation workshops held in Kenya. This initial workshop was aimed at introducing national-level stakeholders to the project and the proposed approach, as well as assessing the uptake and effectiveness of national policies and interventions in the Kenyan agriculture sector and responses to climate change. Participants included representatives from a diverse range of organizations within the agriculture and climate

change space in Kenya, such as government departments, development partners, and farmer groups/organizations.

Current Sub-Sector Policies

Livestock	Crop Subsector	Fisheries
• *Kenya Veterinary practice Bill 2024* • *Animal production professionals and technicians bill 2023,* • *Livestock (breeding) regulations 2023* • *Dairy master plan strategy and action plan* • *Range management and pastoralism strategy* • *State department of livestock strategic plan 2018-2022* • *Strategic plan for MOALF* • *National livestock policy (revised) 2019* • *Sessional paper no. 3 of the livestock policy.*	• *Agriculture Sector Transformation Growth Strategy (ASTGS) 2019-2029* • *Kenya Climate Smart Agriculture Strategy (KCSAS) 2017-2026* • *Kenya Climate Smart Agriculture Implementation Framework (KCSAIF) 2018-2027* • *Climate Smart Agriculture-Multi-Stakeholder Platform Strategic Plan (CSA-MSPP) 2022-2026*	• *Water Act 2016, National Water Policy* • *National Water Harvesting and Storage Strategy* • *National Water Master Plan* • *National Oceans and Fisheries Policy*

While various policies exist, there is a common sentiment that their implementation remains a major challenge. Both national and county governments have made limited efforts to put some policies into practice, and their full impact has yet to be seen at the local level. An example cited was the Rangeland Management and Pastoralism Strategy, which focuses on community land use for grazing and promotes pasture preservation and fodder production to address forage scarcity. While county governments are responsible for implementing this strategy, efforts have been minimal, leaving fodder and forage scarcity as ongoing challenges for pastoral communities. Additionally, participants noted that policies are rarely reviewed, highlighting the need for regular assessments to determine their effectiveness.

Adaptation Needs

Various adaptation needs were identified per subsector, and these are summarized below:

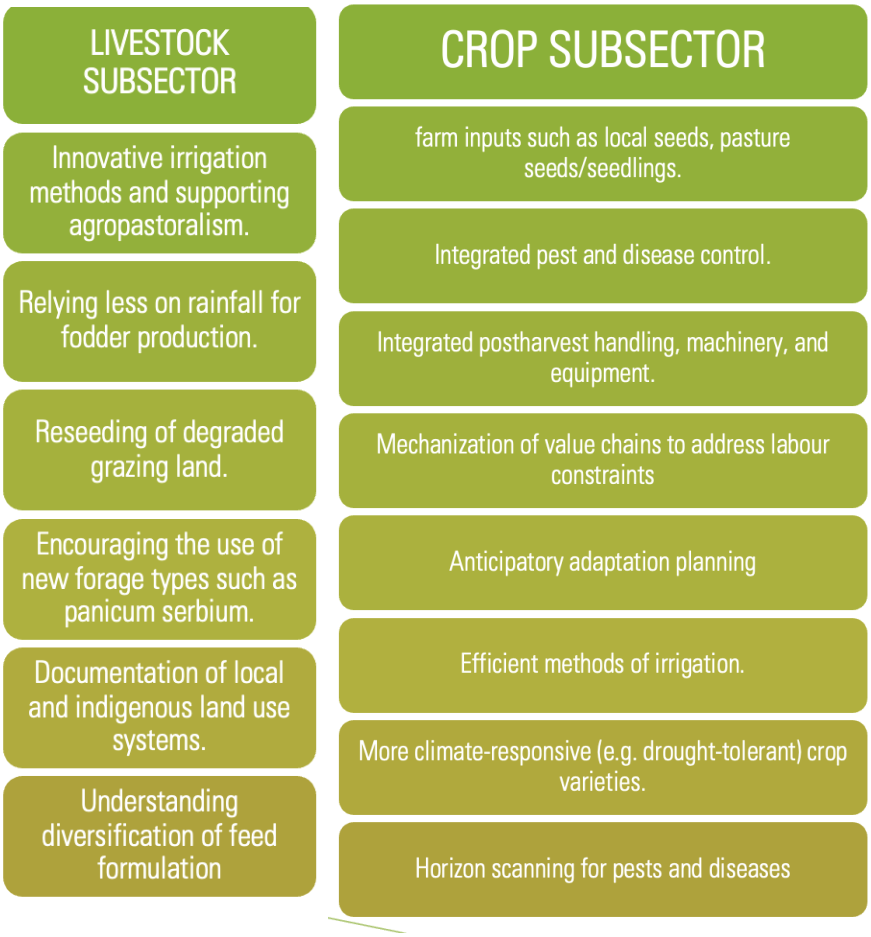

Fig 9: Identified adaptation needs per sub-sector

Research Needs

Actionable research areas were identified based on the stakeholder input at the national level, and these were also classified based on the three subsectors. The following section provides a summary of the research needs.

Livestock Subsector	*Crop Subsector*	*Fisheries Subsector*
• Research at the farm level emissions for	• Documentation along the value chain nodes for adaptation to	• Research/Data to monitor what is affecting fish species

different livestock systems. • Research into dual-purpose crops. Eg Sorghum, wheat & barley • Research on the use of local predictors of weather systems. • Research into shifting herd composition (e.g. cattle to goats, camels as appropriate) • Research into culture and heritage linked to livestock ownership. • Research into emerging disease control. Including rapid detection and response. • Research into carbon markets in the livestock sector • Research into scheduled burning earlier in the season to allow regrowth.	changing climate in crop value chains. • Research into palatable and shelf life of crop products. Such as wheat and rice • Need for research on the maladaptive consequences of some of the local adaptation initiatives. • Research on climate readiness and digital inclusion for smallholder farming systems.	and fish numbers including Tilapia, Nile Perch & Mackerel. • Research into water efficient technology/practices development - to use little water (precisely) to produce more. • Locally formulated irrigation technologies (local technologies) and enhancing partnerships with Technical and Vocational Education and Training (TVETs). • Climate resilience technologies in fisheries. • Research into value chain assessments (how climate change is affecting each aspect). • Research into green technologies for fish storage and preservation.

4.2.1 Sub-National Workshops

4.2.2 Arid and Semi-Arid Lands (ASALS)

Adaptation Gaps

Climate change impacts in their various forms have forced farmers to try out different technologies, innovations and strategies to adapt. In the livestock sector, for instance, fattening involves the purchase of young or small livestock and providing them with water and feed to promote weight gain in the shortest period and thereafter sold at higher prices for increased income. In the crop sub-sector, planting short-term horticulture produce through the kitchen and multi-storage gardens is practised as an adaptation strategy that addresses nutritional requirements and revenue generation to meet other household demands. Planting of drought-resistant and early maturing seeds is other adaptation strategy in the crop sub-sector amongst smallholder farmers. However,

various adaptation gaps still exist, Figure 10 outlines some identified by the farmers. Greenhouse farming especially for horticulture production has been used to deal away with pests and disease infestations and increase production in control environments.

Fig 10: Identified adaptation gaps

Evolution of Gender Roles

As a result of climate change, there have been some observed changes in gender roles with both men and women involved in roles they didn't engage in traditionally. Some of the key shifts include:

- Men have shifted to crop farming as opposed to the past where they were mainly involved in livestock rearing.
- Men have diversified livelihoods into alternative non-farm sources of income such as motorbike operators for transport.
- Men's engagement in poultry keeping has increased despite it being a taboo traditionally in some communities mainly reserved for women.
- Women are increasingly involved in value addition activities such as food preservation techniques especially vegetable preservation.
- Women are increasingly owning livestock unlike traditionally where livestock ownership was for men.
- Women involvement in crop irrigation and fruit farming.
- Women can now use technology to trade, calling to find out the market status (e.g. cellphones and associated digital platforms).
- Involvement of both men and women in fisheries activities where predominantly it was an activity for the men.
- Youths venturing into agriculture including by adoption of climate smart agriculture alternatives and technologies such as hydroponics.

Emerging Research Priorities

Various emerging areas of research were identified based on the agriculture sub-sectors and have been summarized below:

Crop Subsector	Livestock Subsector	Fisheries Subsector
• Research is needed to develop and identify drought-resistant seeds (maize, sorghum, pigeon peas) to enhance resilience in	• Feed formulation using locally available feed resources to improve livestock nutrition and sustainability. • Improving livestock breeds, including locally kept	• Research on modern drying racks and other value-addition techniques to ensure uniform and efficient fish drying processes.

arid and semi-arid lands (ASAL) regions. • Research on the development of natural and organic pesticides that are both environmentally friendly and effective in ASAL regions. • Value addition research is necessary to enhance crop shelf life and improve storage techniques, particularly during times of surplus production. • Research on the development of more efficient and accessible drip irrigation systems for smallholder farmers. • Research on soils to guide optimal fertilizer and seed selection tailored to specific soil types.	livestock like Borana beef cattle, • Upscaling fodder production and conservation techniques during dry seasons. • Best practices for demarcating pastoral lands for wet and dry seasons for effective land management. • Effective immunisation and treatment protocols for maintaining livestock health. • Research on water harvesting techniques to support livestock during dry seasons to ensure water availability. • Market linkages for livestock, to enhance market access and profitability. • Value addition for livestock products, to increase income and sustainability. • Use of GIS to provide data on pasture & resource availability to improve resource management. • Rangeland rehabilitation through soil rehabilitation, grassland re-establishment, and reseeding to restore degraded lands. • Preservation and value addition for camel milk.	• Supporting fish farming practices through research, such as the use of nets over ponds to prevent bird predation and determining optimal conditions for raising fingerlings, is critical. • Promoting fish as a nutritional alternative and income generation source through targeted research can enhance food security and economic well-being.

4.2.3 Central Highlands

Adaptation Gaps

Various adaptation efforts have been adopted in the Central Highlands by smallholder farmers to strengthen climate resilience mechanisms and food production systems. Some of the adaptation efforts across the three sub-sectors include: a shift to drought-resistant and short-season crops, the

use of irrigation systems, water harvesting techniques, the use of supplements increasing livestock productivity, and the rearing of fish in greenhouses, among others. Despite these efforts at various scales, gaps still exist in climate adaptation, and these include:

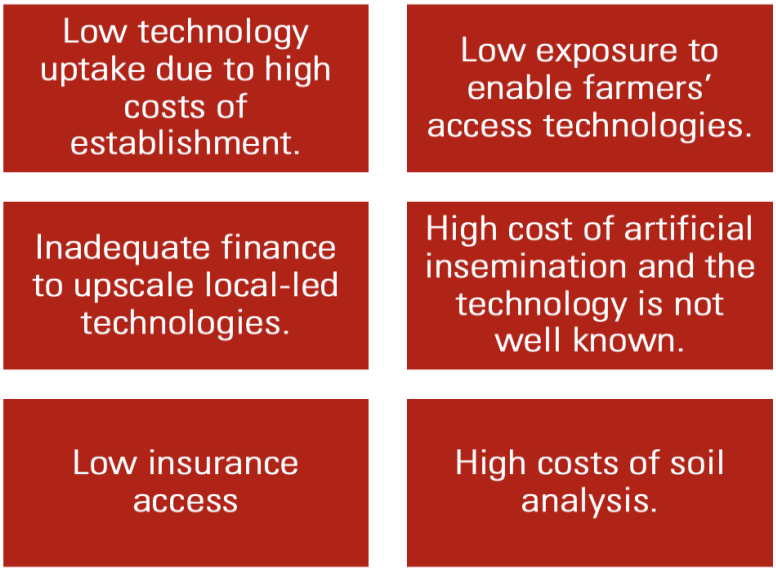

Fig 11: Identified adaptation gaps

Research Priorities

Emerging actionable research priorities identified included:

- Research on the indigenous practice of testing pregnancy on cows through *Croton macrostachyus*.
- Research into existing and emerging feed and fodder nutrients and possible level of toxicity.
- Research into castor seeds as a source of animal feeds.
- Research on Azolla, BSF technology upscaling due to its usefulness during droughts.
- Research on avocado varieties that do well in the region.
- Research into local organic ways to improve soil health – looking at different soil amendment options.
- Market research to provide diversity in global markets options that have better incomes.
- Research on disease and pest control including maize lethal necrosis, fall armyworm, grey leaf spot, and turcicum leaf blight.
- Research and awareness creation on the safe use of agrochemicals and drugs used on animals.
- Research on alternative sources of feed for livestock and fisheries.
- Research on improved livestock breeds either by introducing new breeds or cross-breeding (cattle, goats, chicken).

Evolution of Gender Roles

Climate change has affected livelihoods and the traditional gender roles, thus resulting in evolution in gender roles. Some of the notable changes in the Central highlands of Kenya include:

- Women have become more aggressive to survive through engagement in small medium enterprises and not just farming as it was in the past.
- Women are now selling more traditional vegetables which do well despite the climatic changes.
- Women are embracing kitchen gardening to supplement vegetables.
- There has been an increased ownership of livestock by women.
- Men are shifting to other enterprises e.g. livestock farming and perennial crop farming.
- Youths have ventured into farming and trading horticultural crops and agribusiness to leverage on the crops demand.
- Fish farming is increasingly becoming a livelihood alternative adopted by both men and women.

4.2.4 Western Highlands & Rift Valley

Adaptation Gaps

Overarching gaps were identified by the smallholder farmers that were constraining their adaptation and consequently productivity.

A. Communication and Knowledge Gaps:

- There was acknowledgement that a lot of innovations and technologies are used for adaptation however the flow of information from researchers to practitioners and specifically to smallholder farmers remained limited. The dissemination of results and relevant information was reported to be poor and, in many cases, non-existent. In some cases, misinformation from research spreads to grassroot levels thus counteracting adaptation progress. Farmers also highlighted that some adaptation practices that are promoted are highly context-specific, working in one area and failing at scaling up, hence, need to know what works and where.
- Concerning knowledge gaps, there was inadequate knowledge of feed quality and quantity of feed to provide for increased livestock productivity.
- It was also realised that the current available communication on adaptation lacks simplicity – it is not broken-down to levels understood by smallholder farmers hence lacking relevance (How best can we communicate about appropriate technologies and innovations in smallholder agriculture to farmers?)
- Extension services, which in the past were quite prevalent and very useful have been reduced due to various issues including dwindling government support and this is negatively impacting knowledge dissemination. The few Extension Officers have limited resources at their disposal to discharge their duties and only reach out to a few farmers who in most cases have resources to transport them.

B. Policy Gap

- It was reiterated that the research function is not devolved to counties, research is predominantly being done and driven from the national level without necessarily taking into consideration needs at the county and ward levels. It is noted that there's a need for a policy that will rectify this and give mandates to county-level research institutes and other departments for implementation.

C. Implementation Gap

- The lack of sustainability of technology and practices that are brought by short-term projects and programs hampers appropriate adaptation progress. The negative effects of these projects include: the dependency syndrome of smallholder farmers on handouts from the projects and these end when the projects end leaving the farmers with no sustainable practices they can use to adapt to climate change impacts and lack of ownership of the projects leading to their death shortly after they end.
- The lack of frameworks and indicators to monitor and evaluate adaptation projects came out as a strong implementation gap.
- Another important gap was the lack of financing to bridge what is known through research to be implemented by smallholder farmers affecting the overall implementation of technologies and innovations with the potential to address climate risks in the landscape.
- Project implementation was also reported to lack equity, inclusivity and proper representativeness.

D. Standardization Gap

- It is noted that in the agriculture sector, there are no established standards, especially for seeds and fingerlings in fishing. There was reported a lack of professional ethics which puts farmers off and they don't engage with practitioners hence hampering adaptation progress.
- Strongly outlined as a gap was the lack of demand-driven and locally driven research and increased focus on education and project goals.

Emerging Research Priorities

In these regions, research areas that were identified were very specific to the sub-sectors and none were crosscutting.

Crop

- Research on emerging pests and diseases as heat increases and rainfall is more variable e.g. Passion Fruit Value Chain is being impacted by new diseases not understood by the farmers.
- Research on cost-effective improved technologies for growing mushrooms. More and more farmers are growing mushrooms commercially and since it is a new crop in the market more knowledge and research are needed.
- Research on value addition across a wide variety of crops especially for local indigenous vegetables.

- Research on cost-effective modern farming methods to increase productivity and reduce labour constraints (mechanisation).
- Research on effective adaptable seeds/drought tolerant seeds in the region including for traditional vegetables, maize and wheat among others.
- Research on the attribution of proliferation and emergence of pests and diseases including fall armyworm to climate change and their organic elimination.
- Further research on Climate Smart Agriculture technologies and innovations that suit different contexts for a variety of value chains.

Livestock

- Research on alternative animal feeds/supplements with a particular focus on the nutritional value of the feeds based on available local resources.
- Research on dairy livestock breeds that consume less food and enhance productivity.

Fisheries

- Research on the best management practices for fish farming
- Research on tolerant fish varieties adapted to climate change and with faster growth rates
- Research on alternative fish feeds

Evolution of Gender Roles

- Men were reported to be doing less and less on farms and women doing more
- Women used to go cutting trees in the forest as part of their livelihood, this has reduced due to improved environmental education.
- Women are more involved in farming activities and have been observed to be more organized in farming activities as well as in implementing adaptation interventions. An example was feed formulation for dairy cattle being done by groups of women.
- More women are involved in making poultry houses in Kisii county where predominantly in the past men would do that more.
- Kericho County women do more in tea and coffee farming but men earn most. This was highlighted as a challenge in improving women's participation.
- Improved education of women is improving livestock keeping and land ownership for women.
- Land ownership is still a challenge but is steadily improving.
- Cultural practices improving but still have a hold on the farmers.

4.2.5 Coast & South-Eastern Lowlands

Adaptation Gaps

Identified gaps in adaptation for all sub-sectors included issues in Figure 12.

Fig 12: Identified adaptation gaps

Emerging Research Priorities

Across the three subsectors crop, livestock and fisheries some common research themes emerged. All sectors highlighted:

A. The a need to develop indicators to measure progress in implemented adaptation initiatives or interventions. This is to ensure that they work or to redesign and re-deploy based on the evaluation outcome.
B. Social research into the most appropriate ways to disseminate weather information, training on new technologies to support adaptation and new adaptation interventions.
C. Research into and mapping of seeds, livestock breeds and fish species (inland fishing) that are suitable to the new climate regimes many regions were facing so as to increase productivity across the board.

Research areas specific to the sub-sectors are as outlined below:

Crop

1. Research on best practices for the prevention of pests and predators in rice farming.
2. Enhancing the productivity of crop varieties.
3. Genetic traits of climate-resilient crops need to be studied and understood to improve the available breeds.
4. Development of organic biopesticides.
5. Reclassification of agro-climatic zones.

Livestock

1. Research on emerging pests and diseases in poultry farming and suitable solutions.
2. As poultry farmers deal with less output from poultry i.e. reduced weight in poultry for the same growth period, research needs to be carried out on how to improve the output and on poultry breeds that are less chemically dependent.

Fisheries

1. Research needs to be conducted on locally led cage fishing technologies.
2. Developing sustainable locally resourced alternative feeds for aquaculture fish farming.
3. Enhancing breeding in aquaculture fish farming
4. The regulation of ocean governance and illegal, unregulated and unrestricted (IUU) fishing by international players is an emerging area of research along the Kenyan coast. This was identified as more of a policy intervention than a research area but kept due to the gravity of the issue.

Evolution of Gender Roles

- Reduced rigidity in gender roles: there are no longer clear-cut roles for men and women, both have to support each other in different roles in the agriculture sector
- More women are moving from crop farming to dairy farming which was initially male-dominated.
- Both men and women are moving into alternative livelihoods. Men are now moving more to off-farm activities, and women are also venturing more into agribusiness including the value addition of farm produce.
- Water collection was initially a women's role, but men are also now collecting water using bicycles and motorcycles because of scarcity and the long distances. Typically tap water is not common in every household hence women and children would use wheelbarrows or carry water on their heads for household and on-farm use.
- More women have taken up fishing (both in the ocean and aquaculture) due to food insecurity and to supplement household income and protein. More women were now boat owners to supplement their livelihood whereas predominantly men owned fishing boats.
- There is currently representation of women in leadership in beach management units (BMUs).
- More youth are now engaged in the fishing value chain including fishing.

4.2.6 National Prioritization Workshop

The national prioritization workshop was the culmination of the entire co-creation process. This specific workshop was designed for the presentation of findings from the four (4) sub-national workshops to national-level stakeholders and work on prioritizing action research agenda and scalable adaptation strategies. Participation was drawn from the list of participants from the first national workshop with added representation from all the sub-national workshops. These included: farmers and farmer organisation representatives; technical officers from the Kenya Meteorological Department (KMD), participants from the four (4) subnational workshops, representatives from research organizations (Kenyatta University); State Department of Gender; Adaptation Research Alliance and Bill and Melinda Gates Foundation (BMGF).

4.2.6.1 Process

Highlights of the sub-national workshops were presented with confirmations solicited from the representatives of the sub-national workshops. Interesting anecdotes were also shared, and these are captured under the process outcomes above. Sectoral breakout sessions were utilized to facilitate the prioritization of the action research areas identified from the sub-national workshops. Two guiding questions were designed to facilitate the discussions:

1. From the research areas identified at the sub-national level, what are the priority action research needs that could support adaptation for smallholder agriculture? (rank/prioritize)
    a. **Consider: Per Subsector (Crop, Livestock and Fisheries) and Per Agro-ecological zones (Coastal, Central highlands, Western, ASALs)**
2. What is the justification for the prioritization of these adaptation needs and actionable research areas?

Participants were given a list of identified research areas from the subnational workshops to use as a basis for the prioritization. Participants were to use their industry and practitioner experience to jointly rank the research areas along the categories of *high*, *medium* and *low.* This exercise involved the use of sticky notes placed on the individually outlined research areas. Table 1 highlights the results of the prioritization exercise.

Table 1: Analysis of prioritization of research areas in Kenya

		PRIORITIZATION SESSION			
	PRIORITY AREAS (PER SECTOR)	1 (High Priority)	2 (Medium Priority)	3 (Lower Priority)	Total (Highly selected)
	CROP				
1	Research on new emerging pests and diseases	2	1	3	6
2	Research on value addition	2	3	1	6
3	Research on Drought-resistant seeds	3	1	1	5
4	Methods of Dissemination and Training	10	0	0	10
5	Research on cost-effective modern farming methods	1	0	0	1
6	Reclassification - Agroclimatic Zones	1	0	0	1
7	Research on Soil Heath (Local Health)	3	1	2	6
	LIVESTOCK				
1	Knowledge sharing , capacity building and dissemination	4	4	4	12
2	Brreds and breeding	4	6	2	12
3	Animal nuitrtion	3	3	9	15
4	Animal health	1	0	0	1
5	Water & Conservation	0	2	1	3
	FISHERIES				
1	Dissemination and Capacity Buildng	0	5	8	13
2	Sustainable Feeds for aquaculture fisheris	0	1	1	2
3	Fast growing fish and well adaptable to specific regions	4	2	0	6
4	Emerging technologies in fisheries to enhance production	5	4	0	9
5	Fish farming best practices & Management	1	4	0	5

4.2. Adaptation Gaps Summary

- Consistently throughout the sub-national workshop's dissemination of the agricultural adaptation information including weather forecasts and climate information was the biggest adaptation gap identified. This was in terms of how the information reached the farmers, the format of the information affecting usability, adoption and/or inadequate information linking the scientific research and the locally led adaptation technologies.

Identified actionable research areas summary

- These included research into resilient crop varieties, soil health and fertility improvement, sustainable and innovative technologies in adaptation, and value addition under the crops sector.

- In the livestock sector, improved livestock breeds, cost-effective improved nutrition, emergent pest, diseases, and toxicity management were the priority research areas whereas under the fisheries, priority research areas were sustainable feed sources, value addition and preservation, and enhanced fish farming practices.

CHAPTER 5: ANALYSIS OF OUTCOMES

This chapter focuses on an analysis of the key findings from all the workshops and puts them in the context of existing literature and national policies in fronting prioritized action-oriented research themes in adaptation for smallholder agriculture.

Adaptation Research Priorities

This section outlines key research priorities for adaptation across subsectors: livestock, crop and fisheries, with a supporting literature review that provides a rationale for each priority area.

1. **Crop Sub-sector**

a. Research on emerging pests and diseases

Pests and Diseases have been recognised as a major challenge in smallholder farms across the regions exacerbated by the changing weather patterns. In recent years, the growing threat of pests and diseases has been attributed to climate change (Alfizar & Nasution, 2024). For the smallholder farmers, the pests and diseases that have been of great concern include: Migratory Pests such as Fall ArmyWorm, African ArmyWorm, Locusts (Tree Locusts in the ASAL region) and Diseases such as Fungal, Powdery Mildew and Anthracnose (Blackish specs in the bananas or brown layering on green pods), Cigar Head in Bananas & Mangoes, and Thrips and *Tuta Absoluta.* Outbreaks of African Armyworm *(Spodoptera exempta)* are particularly frequent across Kenya. According to CABI Africa, outbreaks of armyworm in mid-2008 were reported in 24 districts in Kenya, damaging **10,324 hectares of crops** and **41,435 hectares of pasture** *(*Carlos Arce & Jorge Caballero, 2016*).* This demonstrates the extensive impact of pests on agricultural productivity and food security in Kenya (Cherotich S. et al., 2023).

As global temperatures rise and weather patterns become increasingly unpredictable, ecosystems undergo changes that create new opportunities for pests and diseases to thrive. The growing presence of pests and diseases due to climatic shifts significantly impacts crop yields and raises costs for pest control, which affects food security and the livelihoods of smallholder farmers. Integrated Pest Management (IPM) strategies are evolving to incorporate biological controls, resistant crop varieties, and regional monitoring systems to respond proactively to pest outbreaks.

However, significant gaps remain, particularly in understanding how climate change affects pest behaviour and the effectiveness of management strategies. Additionally, farmers have adopted the use of indigenous practices such as the use of ash, chilli and other techniques for pest control. Farmers are also concerned about the overuse of chemical-based pest control methods, to deal with these emerging pests and diseases, that affect the quality of food for their local consumption and for market access. Research into organic pesticides would go a long way in enhancing productivity and promoting One Health.

Kenya's recently released 3rd National Climate Change Action Plan (NCCAP3) acknowledges the emergence of pests and diseases and the extension of the geographical zones for their occurrence

due to climate change with impacts on crops, and livestock. The Plan proposes research to enable "A national program on Monitoring, Control and Surveillance of pests, diseases and invasive species in forestry linked to the forest information management system is implemented." This focuses solely on forestry but leaves out crops and livestock sub-sectors demonstrating a need for research in these sub-sectors to support adequate adaptation planning. This further demonstrates the value of co-creation in determining national priorities.

b. Research on Value Addition

Value addition in agricultural production is a strategic approach to reduce post-harvest losses; address market access challenges by extending the shelf life of perishable goods and increase farmer revenue (Bahati et al 2023). According to the Kenya National Bureau of Statistics, Kenya loses over Kes 100 billion worth of food annually through poor postharvest management as farmers struggle to manage, store, and transport their produce to the market. Maize farmers for example incur post-harvest losses through damage by insect pests, rodents, poor handling and aflatoxin. Other produce that registers high post-harvest losses includes bean-type cereals, sorghum, millet, Irish potatoes, sweet potatoes, dairy products and horticultural produce including vegetables, fruits and flowers. Notably, the ASAL regions experience high ambient temperatures which affect the post-harvest quality and reduce loss of produce due to poor post-harvest management technologies. Solar dryers, for example, use high temperatures to remove moisture from crops like fruits, vegetables, and grains. This method reduces perishability and allows produce to be stored or transported to markets without a significant drop in quality. Such techniques are simple yet scalable and suitable for resource-limited smallholders, especially on innovations based on local resources.

NCCAP3 under the Food and Nutrition Security priority highlights plans within the crop and fisheries sub-sectors to

1. *"Develop, promote and transfer technologies to enhance value addition and product diversification for tea, cereals and nuts"*
2. *"Youths trained on value addition in fisheries and blue economy"*
3. *"Support to develop, promote and transfer technologies to enhance value addition and product diversification for fish, fish feed and seaweed"*

Farmers indicated a need for research into more than these outlined crops including local vegetables demonstrating a gap in existing research and creating an opportunity for research to focus on this area. This argues the case for locally led adaptation research and the use of co-creation in determining these research needs. Some of the local innovations proposed in preservation that require verification of their efficiency include: the use of Ash for preservation and underground Storage of sorghum (*Dig a hole, burn the hole, place the sorghum inside, add grass and cover, this helps preserve the dried sorghum*)).

c. Research on Drought Tolerant Crops & Varieties

The move to drought-tolerant crops is meant to address the increasingly variable weather, specifically fewer seasonal rain days, prolonged dry spells with associated moisture stress and more frequently recurring droughts, especially in ASAL regions. Tesfamichael *et al* in their 2017 paper found that particularly with respect to maize a regional staple, drought-tolerant varieties increased productivity and reduced downside risk, contributing to poverty reduction. They also mention that mainstreaming drought-tolerant maize varieties into national climate change adaptation plans will be important. In addition, particularly for farmers in the Western and Rift Valley Region, the passion fruit value chain was recognised as one to have the potential to withstand the dry seasons, since it is easy to grow, a low cost of production. However, most farmers have cited low productivity due to attacks by pests and diseases (*Karani-gichimu et al., 2013*).

The participants highlighted that there is a need for research on developing and identifying **appropriate and cost-effective drought-tolerant seeds to increase resilience.** They also identified the need to develop local seed systems that are adaptable to the local climates and the Open Pollinated Varieties which have potential to produce more.

NCCAP3 mentions drought tolerance twice with reference to trees and forestry, a missed opportunity to incorporate local needs.

d. Research on Cost-effective Modern Farming Methods

There is a growing necessity for the complementarity of traditional to modern agricultural practices depending on what works in different contexts. Devendra (2010) has argued that the adoption of modern technologies is critical to improving the productivity of farmers' economic performance and the long-term viability of the agricultural sector. The use of modern techniques promotes the productivity of crops in small parcels of land. New techniques are used by the farmers but the rate of adoption of new technologies is slow due to a lack of awareness among the farmers on the cost-effective modern farming methods. Such new techniques include organic farming, genetically modified crops, kitchen gardening, vertical farming and greenhouse farming. Climate-smart agriculture which has also been introduced to many smallholder farmers is also slowly taking hold. Predominantly farmers in low rainfall areas highlighted this need which would additionally include cost-effective moisture conservation strategies for the different soil and crop types. Modern farming methods are projected to increase productivity in the small parcels of land owned by smallholder farmers.

NCCAP3 outlines plans to "*Deploy modern agricultural risk management instruments, crop and livestock insurance schemes, commodity market instruments such as forward contracts, futures contracts and price stabilization schemes to ensure farming is profitable and income is predictable*"

e. Re-classification of Agroclimatic zones

Climate change is significantly altering the characteristics of climate zones, which drives agricultural land use and ecosystem change. Kenya's land area covers a very wide range of ecological zones and is divided into seven main agroclimatic zones: Arid and Semi-arid Lands (ASALs), Central highlands, Coast, Rift Valley, Western and Eastern regions. Reclassification of agro-climatic zones was suggested as a research area as farmers consider it an essential step to determine the most

suitable crops within each zone. The agroecological zones give an indication of what may be grown in a particular area.

f. Research on Local methods of enhancing soil health

Soil health is defined as the continuous capacity of soils to function as a vital living ecosystem, sustain biological productivity, maintain the quality of air and water, and promote plant, animal and human health. Declining soil fertility is a persistent constraint to agricultural production especially in the Central Highlands region where soil acidity is a concern, thus posing a threat to food security and livelihoods of smallholder farmers. Research is needed on local methods of enhancing soil health including both organic and safe inorganic methods, understanding the recommended levels of fertilizers, soil amendment options; as well as fertilizers that are friendly to acidic soils.

2. Livestock Sub-sector

a. Augmenting Animal Nutrition

Climate change is significantly impacting animal nutrition, reducing both the availability and quality of feed. Prolonged droughts diminish water resources, rangelands degradation and degrade feed crops leading to increased livestock feed shortages, consequently, livestock deaths, poor quality livestock, and decreased revenue for livestock producers. Competing access to pastoral lands was identified as one of the primary causes fueling conflicts between communities especially in the ASALs. From the 1970s livestock kept in rangeland regions have steadily declined. Cattle populations have fluctuated while sheep, goat and donkey numbers showed declines of up to 10-14%[1]. Camels increased by 12% possibly due to their high tolerance to increasing drought conditions. As climate variabilities continue to intensify, alternative and affordable feed sources become increasingly urgent for sustainable livestock management, which is the niche for research on alternative livestock feed. In addition to listing drought-tolerant livestock feeds, capacity building on feed management, and alternative feed sources as priority areas for research under animal nutrition, there was also emphasis on the need to find alternative ways to increase access to water resources.

b. Animal Health

Heavy rainfall and prolonged droughts disproportionately affect livestock health, causing increased outbreaks of pests and diseases. Literature confirms that Foot and Mouth disease, Contagious Caprine Pleuropneumonia, East Coast fever, and Enterotoxaemia among others are experienced by most pastoralist livestock farmers[2]. Prolonged droughts also cause heat stress to the livestock affecting their normal eating habits, thereby reducing livestock growth rates and productivity.

[1] Ottichilo, W.K., Grunblatt, J., Said, M.Y., Wargute, P.W. (2000). Wildlife and Livestock Population Trends in the Kenya Rangeland. In: Prins, H.H.T., Grootenhuis, J.G., Dolan, T.T. (eds) Wildlife Conservation by Sustainable Use. Conservation Biology Series, vol 12. Springer, Dordrecht. https://doi.org/10.1007/978-94-011-4012-6_10

[2] https://pmc.ncbi.nlm.nih.gov/articles/PMC10337939/

During heat stress, livestock is more susceptible to diseases and, in worst-case scenarios, leads to decreased fertility to the livestock. To avert these harsh impacts that might result in losses to the smallholder farmer, alternative livestock breeds that are productive, tolerant to pests and diseases, and heat stress were identified as priority research areas. Additional research areas could include alternative treatment methods including organic medicine, local interventions that could be scaled and anticipatory, preventative approaches.

c. Water Conservation

So critical is this component that it was reiterated in all the sub-national workshops regardless of the arid and the semi-arid regions. Unlike the ASALs, other regions had a mild concern on water conservation highlighting the need for water dams within their regions. Priority research areas for the ASALs included how they can conserve their surface water considering they are already experiencing erratic weather patterns. While interventions like increased boreholes, water pans, and irrigation systems were suggested by the smallholder farmers from the ASALs, they insisted more should be done on water conservation, providing a solution that is long-term and sustainable.

d. Research into new Breeds and Breeding best practices

While calling for newer breeds that are hardy and tolerant to harsh conditions, more emphasis was on the need to integrate the native breeds that are able to withstand harsh environmental conditions but are not particularly productive. Thus, research should focus on breed combinations that produce tolerant breeds for different environments. Local knowledge was also highlighted as a very important component to breeders to avoid breeding breeds with lower traits to withstand erratic environmental conditions but also avoid negative impacts on animal breeding. Crossbreeding indigenous and exotic breeds, such as *Sahiwal* and *Friesian* cattle, was highlighted as a practice to enhance adaptation. This is exemplified by the **Kenya-India collaboration on dairy farming in Nyeri**. Locally adapted livestock, such as Borana beef cattle, were identified as key to enhancing productivity. The Sahiwal breed, valued for its multipurpose traits, is gaining preference over the Borana breed as part of efforts to improve livestock resilience and productivity. The farmers highlighted the need for research to ascertain the most productive breeds that require minimal effort. Most farmers practised naturally uncontrolled breeding of goats but indicated a need to have pure breeding based on research to enhance livestock resilience.

3. Fisheries Sub-sector

a. Research into Sustainable Feeds for Aquaculture Fisheries

Research efforts should also be focused on developing sustainable feeds based on local resources for fish farming. Approximately 70% of total production in fish farming is covered by commercial feeds which are expensive to the smallholder farmers. The Kenya Fisheries Service reports that production from low-input smallholder farmer systems amounts to about 500-1500 kg/ha/year[3];

[3] https://kefs.go.ke/sites/default/files/A%20COMPANION%20FOR%20FISH%20FARMERS%20IN%20KENYA%20%281%29.pdf

there is a need for locally available feeds that are of good quality and affordable. Such research efforts are projected to enable communities to venture into fish feed production which can be an alternative source of livelihood besides fish farming. For the farmers to actualize high profit margins, it is imperative to have access to well-balanced nutritive and cost-effective feeds, backed by sound on-farm feed management practices.

b. Scaling of Best Management Practices of Fish Farming

In the ASAL region, the high-priority research needs were determined to be around best practices that support improved fish farming. Research into methods such as the use of nets over ponds to prevent bird predation and determining optimal conditions for raising fingerlings. Such research-driven practices are expected to directly influence production and increase the resilience of fisherfolk to changing climate conditions. Additionally, the research into the best management practices is expected to guide the selection of suitable fish species adaptable to the area/location and promote the use of appropriate fish methods & gears contributing to the sector's sustainability.

c. Research on Emerging Technologies in Fisheries to Enhance Production

To achieve rapid transformation in the fisheries sector, there is a need to scale emerging technologies and innovations to accelerate the productivity of the sector. This type of research is expected to reduce the cost of production and promote aquaculture management. Research should focus on emerging innovative technologies ranging from culture systems including feed formulation - which should be based on scientific data and considers both the macro- and micronutrients required by the fish, pond technologies, breeding and genetics (selective breeding); fish health; to post-harvest loss reduction, value addition and marketing. These technologies have great potential to increase tilapia production and profitability to positively impact the local livelihoods of smallholder fish farmers through the creation of employment, economic growth and better nutrition.

d. Fast Growing Fish Adaptable to Specific Regions

Additionally, research should focus on fish species with faster growth rates, particularly genetically early-maturing species, to enhance productivity. This research aims to reduce the culture period of fish, thereby lowering production costs. This is expected to support the farmers in planning and mitigating the risks of climate extremes. One of the priority research needs in the Coastal and Eastern Region, is specific breeds (fast-growing) suitable for inland fish farming. To solve this, research on YY fish species and the production process of YY species was highlighted as a probable solution. However, research is needed to identify the best approaches to the production of all male populations to increase production. As such, hormonal sex reversal by feeding fry with different hormones is the most common method used to produce all-male populations. However, the use of this method is increasingly being criticized. The accumulation of hormones in the environment, and an increasing number of consumers who are not interested in eating products that have been treated with hormones have led to a search for alternative techniques for the production of all-

male populations. Most of the farmers practice sex reversal where the tilapia larva is fed with testosterone-induced feeds resulting in a monosex male tilapia which grows faster and bigger.

In commercial farming of Nile tilapia, uncontrolled reproduction during the grow-out phase leads to overcrowding in ponds, causing competition for resources and resulting in a variety of fish sizes rather than the uniform, larger fish expected at harvest. Mixed-sex tilapia is generally discouraged as it produces up to a billion eggs leading to competition for food, and stunted growth. To address this issue, farmers in the Central Region, who raise mixed-sex species, introduce catfish into the ponds as a biological control measure. The catfish feed on the excess tilapia juveniles, helping to manage population size and reduce overcrowding thereby supporting healthier growth rates and more uniform fish sizes.

4. Cross-Cutting Research

a. Research on Knowledge Sharing, Dissemination and Capacity Building

Across the regions and sub-sectors, there was a critical need to identify techniques for dissemination and training on the proper use and implementation of adaptation strategies and climate information. In addition, the farmers proposed that there is a need for research on effective dissemination and training techniques, mainly on the implementation of adaptation interventions. Agricultural-related information including climate services, adaptation technologies and innovations is imperative in ensuring the use of best practices that increase productivity and build resilience to climate risks. However, smallholder farmers across the regions seldom feel the impact of agricultural innovations either because they do not have access to such vital information or because it is poorly disseminated. Consequently, there is a knowledge gap amongst farmers on best practices to use in the face of climate change. Notably, there are some limiting factors to agricultural information dissemination including status differences between extension agents and the farmers; extension agents' inadequate knowledge of how communication works; and the extension agents' lack of interest in traditional knowledge to disseminate the information. More important, is the question of how to best package the information so that it can be consumed by smallholder farmers. The information needs of the farmers span around, agricultural input; extension education; agricultural technology; agricultural credit; insurance and marketing.

b. Scalable climate adaptation strategies across landscapes

Coastal and Eastern Region:

Use of zai pits as a water conservation technique

Crop Subsector

Water harvesting (terraces, farm ponds) and mulching.

Livestock Subsector

Shifting to goats and poultry, fodder preservation, and livestock migration.

Fisheries Subsector

Smoking vessels for durability and production of fish food to reduce costs. Conservation of coral reefs and mangroves

ASAL Region:

- Drought-tolerant crops and varieties
- Moisture conservation (mulching, intercropping)
- Re-seeding pastures
- Terracing for dealing with flooding
- Planting napier grass along fields to address flooding
- Water holes along fields for trapping water/moisture
- Post-harvest preservation (moisture determination)

Livestock Subsector

Fattening of livestock, Reducing the number of animals: Shifting to smaller ruminants (goats, sheep) and poultry. Grazing management: fodder preservation, and increasing water sources (water pans, boreholes). Commercial fattening and introducing high-yielding livestock breeds

Central Highlands Region:

- Walking tractors for mechanization and address labour constraints – CROPS
- Sweet Irish potato farming (tolerant to acidity)
- Azolla production

Crop Subsector

Early maturing and drought-tolerant varieties, Drip irrigation, water harvesting, and specialization in commercial crops.

Livestock Subsector

Use of supplements, Artificial insemination, Use of sex semen, and Zero grazing. Preference for small animals (e.g., goats) due to lower fodder requirements.

Fisheries Subsector

Increased fish farming through water harvesting and use of solar aerators. Greenhouse fish farming.

Western Region and Rift Valley Region:

Crop Subsector

Micro-irrigation in Fruit Farming

Livestock Subsector

Transition from Indigenous to improved breeds (e.g improved Kienyeji), Use of Supplements for animal feeds

Fisheries Subsector

Use of Black soldier fly larvae as fish feeds, Diversification to drought-tolerant varieties

Target Actors

Collectively participants at the National prioritization workshop worked on identifying actors including partners to work on the identified prioritized research areas. These are outlined as follows;

Subsector	Actors
Crop	**Research Institutions**: Kenya Agricultural and Livestock Research Organisation (KALRO), Consortium of International Agricultural Research Centers (CGIAR), KEPHIS, **Media**: Vernacular Radio Stations, Digifarm, Shamba ShapeUp, **Public and Private Extension Service Providers**: Farmer Field Schools, Lead Farmer), Mercy Corps, **Farmer Organisations(Cooperatives)**: CBOs, Youth Groups, PWD Groups, Faith Based Organisations, **Government Institutions:** Kenya Agricultural Observatory Program (KAOP) and **Others** including: Agro Dealers, Climate Experts, Kenya Meteorological Department (KMD), Local Administrators,, Indigenous Knowledge Experts, Microfinance Institutions, Village Based Advisors (Demos- Superdemos, Mother demos), Beach Management Units (BMUs), CFAs, Academia
Livestock	**Research Institutions**: International Livestock Research Institute (ILRI), Heifer International, Kenya Animal Genetics Resource Centre (KAGRC), KALRO, Agricultural Development Cooperation, **Government Departments**: Ministry of Livestock, **Producers**: Kenya Livestock Producer Associations, Individual Producers, Kenya Veterinary Vaccines Production Institute and KenChic, SNV, Feed Manufacturers (with some having silage for sale), SmallScale Producers, **Academia**: Kenyatta University , Egerton, Tegemeo Institute, Bukura, JKUAT Campuses such as Kenya School of Government (KSG), Agricultural Training Centres (ATCs).
Fisheries	**Research Institutions**: Kenya Marine and Fisheries Research Institute (KEMFRI), **Academia**: Agricultural Training Centres, **NGOs**: FarmAfrica, GATSBY, **Government**: County Gvt, National Govt and other partners, Kenya Fisheries Service, Aquaculture Association of Kenya, Aquaculture Business Development Program, Youth Fund, **Suppliers** such as Fish feed suppliers, Fish Processors, Beach Management Units (BMUs), Cooperatives, Fish Traders, Development Partners, Lake Basin Development Authority, Africa Enterprise Challenge Fund,

CHAPTER 6: CONCLUSIONS & RECOMMENDATIONS

6.1. Conclusion

The smallholder agriculture co-creation process employed in determining action research priorities and scalable adaptation strategies is inclusive and considers the positions of different stakeholders through consultative actions. With the objective being to accelerate smallholder agriculture adaptation this approach allowed the AGNES team to capture context-specific climate-related risks and challenges to adaptation as well as successfully deployed interventions. Working with national-level stakeholders to prioritize the surfaced research needs had two-fold positive benefits which are:

1. Allowed for practitioners and researchers to apply their expertise in determining the way forward for research in adaptation in Kenya.
2. Exposed the experts including researchers and policymakers to information they would typically not have from the sub-national contexts to support research design and policy formulation.

These co-creation workshops also provided room for peer-to-peer learning, networking and opportunities for funders, agribusiness practitioners, government officials and farmers to exchange contacts and set up modalities for work and improved access to information.

6.2. Recommendations for BMGF

Based on the prioritization of the research areas the following priorities fall under the BMGF thematic and fundable areas.

1. **Climate Services**

   Across all sub-sectors and regions, the category of dissemination, knowledge sharing, training and capacity building on climate information services was the most popular choice as a priority research area. [See Table 1] Key discussion points were that climate information needs to be packaged in a way that smallholder farmers can easily access, understand and use for the implementation of their farming systems. The same extended to technology transfer. Investment along this thematic area could focus on co-designing climate services for smallholder farmers that incorporate early warning for different climatic risks. Collaboration between the County Meteorological Offices, extension services and the farmers could lead to the development of a suite of products at different time scales to support both long and short-term adaptation planning as well as day-to-day on-farm activity planning.

2. **Water Resources Conservation**

   Given that Kenya is classified as a water-scarce country, most farmers expressed the urgent need to invest in more research on water conservation so as to ensure availability throughout growing seasons. Farmers expressed the need for research into low-cost, energy-efficient and gender-sensitive irrigation facilities.

3. **Soil Management**

Soil health was identified as one of the priority areas under the crop subsector. Likewise, water and conservation are under the livestock subsector. Most farmers were concerned about how to maintain and manage soil health in their farms as well as how to effectively utilize dwindling water resources and practice conservation.

4. Increasing Private Sector Investment in Adaptation

   Farmers and stakeholders likewise felt that government services need to be supplemented by private sector actors due to capacity issues and the potential for the private sector to benefit from increased productivity. This cuts across all research areas that emerged from the prioritization exercise.

5. Locally Led Adaptation

   Throughout all the subnational workshops and at the prioritization workshop, it was evident that adaptation planning in agriculture needs to include the local farmers. Therefore, any future research into adaptation strategies especially in other countries would benefit from similar co-creation activities to surface the actual needs based on local risks and contexts.

6. Generating high-quality data and evidence

   Stakeholders highlighted the need to create systems and invest in research into indicators to measure progress in adaptation in the agricultural sector as done by smallholder farmers. This is projected to lead to the generation of useful data that can be used to invent or plan for effective adaptation plans. This audit of sorts of the existing implemented adaptation interventions is likely to "*show what's working and what is not working*".

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ANNEXURES

1. Sub-regional reports
2. Guiding questions
3. Stakeholder Analysis
   https://docs.google.com/document/d/1YVG70mcRRmJDXgSJ5NXqgFfAj5VfZ3_J/edit?usp=sharing&ouid=115971123866999333298&rtpof=true&sd=true

The stakeholders were selected from different sectors of agriculture and from different levels of their value chains to ensure diversity. In Addition, gender distribution and inclusivity of participation were key for the representation of all groups in the sector. The stakeholders were categorized as follows:

	Participants Summary Matrix							
		Isiolo Sub-National	Nyeri Sub-National	Kitale Sub-national	Mombasa Sub-National	1st National workshop	2nd National workshop	TOTALS
1	Male	15	14	20	24	13	17	103
2	Female	11	11	12	9	12	17	72
3	Youth	3	7	7	7	5	11	40
4	Farmers	12	13	19	25	2	11	82
5	County Agri directors	4	2	8	4	2	6	26
6	Sub-County Extension officers	7	6	1	1	-	-	15
7	County Director Meteorology department	1	3	3	4	-	1	12
8	County Chief Officer-Agriculture	-	1	1	1	-	-	3
9	Farmers cooperative representatives	7	-	5	3	2	5	22
10	PWD Representative /Marginalized Rep	1	-	1	-	3	2	7
11	Women Farmers Association/ Gender Representative	1	1	-	1	3	4	7
12	Private partners				1	1	1	3

	(Agri-Sector)							
13	Research Institutions/ Universities	-	-	-	-	5	4	**9**
14	NG0's					10	9	**19**
	TOTAL NUMBER OF PARTICIPANTS	26	25	32	33	25	34	**175**

4. **Satisfaction Surveys - Survey Summary Feedback -** https://docs.google.com/document/d/1ggYOIqQUCecpFETEO13jk_zNiJqGBYQP/edit?usp=sharing&ouid=115971123866999333298&rtpof=true&sd=true

A. What was the most valuable part of the workshop for you?

- Group discussions
- Knowledge and skills gained
- Having different genders give different views in different groups. Teamwork demonstrated in the groups especially women being separated made them open up
- Networking and gained new friends
- Learning about different farming methods
- Social interaction and learning from other Counties.
- Learnt from peers and will cascade the same to others
- Socio-economic impact of climate change on smallholder farmers, local early warning systems, gender issues.
- Interactive and in depth discussions- forum gave opportunity for everyone to give ideas and opinions
- Interaction with experts
- Identifying adaptation needs and gaps and research priorities
- Identification of gaps of various sections and how to address them.

- Shared experiences from different Countries, specifically the gaps and needs of the adaptation.
- Adoption in gender activities that increase productivity.
- Views of pastoralists and agro pastoralists on climate adaptation efforts
- New adapted technologies in farming.
- Interaction with different women/men from other areas and seeing issues that affect them
- Understanding of what adaptation means
- Discussions on projected climate risks on different agricultural sectors and how farmers have adapted to climate change
- Adaptation and measures. Early warning systems and timely preparedness

B. What suggestions do you have for improving the workshop?

- Share and cascade the discussions to SMEs.
- Engage other Counties
- Meet farmers on the ground next time. Can be communicated through CBO
- Add number of participants to accommodate more areas
- Have more trainings on climate change, Exposure tours about Agriculture
- Implement training of trainers (ToTs)
- Provide more days for the workshop, consider adding facilitation fees
- Bring more youth on board for them to take up more roles in agriculture
- Bring more experts to the workshop
- Participants to be allowed to look for their own accommodation .
- The way they did it was good. Keep it up!
- Add the number of participants who are farmers. Representation at ward level.
- Sessions were interactive and engaging, I would encourage the team to continue with the same process.
- Training to be held at the grassroot level and community mobilizers to be trained as ToTs, Farmer service centers to be enhanced. Needs exposure learning and networking. Thanks and we appreciate for the knowledge gained on adaptation