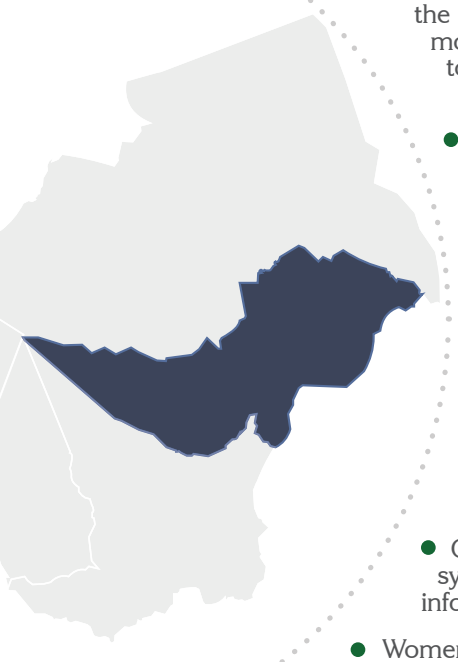
Climate Risk Profile
Tharaka Nithi County

Highlights

- The main occupation of the people of Tharaka Nithi County is agriculture, which includes both crop and livestock production. An estimated 80 percent cent of the county's population is engaged in agricultural activities while agricultural production occupies 1,449.6 km2 of arable land in the County. Approximately 43,799 hectares is under food crops while 14,839 hectares is under cash crops.
- Over 40 percent of the county's population lives below the poverty level (less than 1 US$ a day) and has challenges accessing basic human necessities like food, clothing, and decent shelter. This is attributed to lack of resources to invest in the other sectors that can enhance their capacity to generate income, poor infrastructure, low food productivity, and adverse climatic conditions.
- Historic climate trends in the last decades showed a moderate increase in temperature in both seasons and an increase in rainfall in the second wet season (July-December). Future climate projections for the years 2021- 2065 indicate that the County will remain highly susceptible to more days with moisture stress and continued moderate increases in temperatures. There is however expected to be a moderate decrease in length of drought spells as well as a slight decrease in intense rain expected in the first season.



- Some of the current crop-related coping strategies to climate hazards for agriculture and livestock farming systems in the county include; small scale rainwater harvesting, implementation of good agricultural practices, and conservation agriculture, planting drought-tolerant and early-maturing varieties, post-harvest management, and agro-forestry. Longer term adaptation strategies for crops include enhanced water harvesting, irrigation development, scaling up of conservation agriculture and efficient irrigation.
- For livestock current coping strategies include storing and conserving pastures and fodder, routine vaccination, deworming and vector control to maintain animal health, controlled movement of animals, improved animal housing, and improvement of milking hygiene. For longer term resilience building key actions include decentralized veterinary services, continuous disease surveillance, capacity building on stock route and market inspection, improved water harvesting, investment in cold storage facilities, capacity building on animal heat management, improved slaughter houses and training on preservation and value addition techniques.
- Off-farm efforts to increase resilience to climate change include services such as early warning systems, expansion and capacity building of agricultural extension and improvement of marketing information and infrastructure.
- Women and youth are among the most vulnerable groups in the county, with the lowest adoption rates of adaptation strategies. There is need for more initiatives geared towards job creation and alternative livelihoods particularly for women and youth.
- There is need for improved weather forecasting, introduction of better-adapted livestock breeds, food processing, and preservation techniques. Farmers need reliable information to understand the urgency of adapting to climate change by being able to access appropriate extension services in a timely manner. However, the capacity of these institutions to effectively deliver the services is constrained by limited funds and human resource capacity. Successful implementation of climate adaptation strategies requires strengthening of the institutional and financial capacity of the respective stakeholders.

KCSAP
Kenya Climate Smart Agriculture Project
Republic of Kenya
WORLD BANK GROUP

List of acronyms

ASDSP	Agricultural Sector Development Support Programme
ASDS	Agricultural Sector Development Strategy
CREEK-K	Center for Research in Environment Kenya
ICE	Institute of Culture and Ecology
IDA	International Development Agency
GRADIF-K	Grassroots Development Initiatives Foundation-Kenya
KACCAL	Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands
KALRO	Kenya Agricultural and Livestock Research Organization
KAPP	Kenya Agricultural Productivity Programme
KAVES	Kenya Agricultural Value Chain Enterprises
KCEP	Kenya Cereal Enhancement Programme
KCSAP	Kenya Climate-Smart Agriculture Project
KFS	Kenya Forestry Service
KPHC	Kenya Population and Housing Census
KNBS	Kenya National Bureau of Standards
KMD	Kenya Meteorological Department
KRC	Kenya Red Cross
KWS	Kenya Wildlife Service
MoLAI	Ministry of Lands, Agriculture and Irrigation
MoALF	Ministry of Agriculture, Livestock and Fisheries
MoWI	Ministry of Water and Irrigation
NDMA	National Drought Management Authority
NEMA	National Environmental Management Authority
RIDEP	Rural Initiative Development Kenya
USAID	United States Agency for International Development
UNDP	United Nations Development Programme
VCCs	Value Chain Commodities

Foreword

Climate change is becoming one of the most serious challenges to Kenya's achievement of its development goals as described under Vision 2030. Kenya is already highly susceptible to climate-related hazards, and in many areas extreme events and variability of weather are now the norm; rainfall is irregular and unpredictable; while droughts have become more frequent during the long rainy season and severe floods during the short rains. The arid and semi-arid areas are particularly hard hit by these climate hazards, thereby putting the lives and livelihoods of millions of households at risk.
In 2010, Kenya developed a National Climate Change Response Strategy (NCCRS) which recognized the importance of climate change impacts on the country's development. This was followed by the National Climate Change Action Plan (NCCAP) in 2012 which provided a means for implementation of the NCCRS, highlighting a number of agricultural adaptation priorities. The focus of these initiatives has been at the national level, and there is need to mainstream climate change into county level policies, programmes, and development plans; therefore ensuring locally relevant, integrated adaptation responses with active involvement of local stakeholders.

The Government of Kenya (GoK) through the Ministry of Agriculture, Livestock and Fisheries (MALF), with funding by the International Development Agency (IDA-World Bank Group) is therefore implementing the Kenya Climate-Smart Agriculture Project (KCSAP). This projects objective is to increase agricultural productivity and build resilience to climate change risks in targeted smallholder farming and pastoral communities in Kenya, and in the event of an eligible crisis or emergency, to provide immediate and effective response. This Climate Risk Profile has been conducted within the framework of KCSAP and aims to inform county governments and stakeholders on the climate change risks and opportunities for agriculture so they are able to integrate these perspectives into county development.

This document presents the Climate Risk Profile for Tharaka Nithi County, which has a climate vulnerability index of 0.388[1]. Despite the modest vulnerability index relative to the national index of 0.431, the county is adversely affected by extreme weather events, mostly drought, moisture stress, and high temperatures. Analysis of historical climate data shows a decline in rainfall, especially in the long rains season since the 1970s[2], alongside an increase in temperature[3]. These factors have reduced water availability in the county and constrained agricultural production; crop failure can be up to 100 percent. For instance, in 2013, farmers especially in the marginal mixed farming zone lost their entire crop[4]. Such an event usually leads to high food prices, rendering many households in the county food insecure. Food aid or relief is a common intervention in the county; for instance, in 2013, more than a quarter of the schools were under school meals programmes. In addition, in response to the negative impacts of climate anomalies, several interventions including irrigation projects and seed distribution programmes among others have been implemented in the county. However, the scale of intervention and adoption is low, and the effects of unpredictable weather are still rampant owing to an array of institutional, political, and socio-economic challenges. Removal of these barriers will bolster resilience against climate vagaries.

The profile is organised into six sections, each reflecting an essential analytical step in understanding current and potential adaptation options in key local agricultural value chain commodities. The document first offers an overview of the county's main agricultural commodities key for food security and livelihoods as well as major challenges to agricultural sector development in the county. This is followed by identification of the main climatic hazards based on the analysis of historical climate data and climate projections including scientific assessment of climate indicators for dry spells, flooding and heat stress among other key climate hazards for agriculture. The document continues with an analysis of vulnerabilities and risks posed by the hazards on the respective value chains. Based on these vulnerabilities, current and potential on-farm adaptation options and off-farm services are discussed. The text also provides snapshots of the enabling policy, institutional and governance context for adoption of resilience-building strategies. Finally, pathways for strengthening institutional capacity to address climate risks are presented.

1 Source: GoK; UNDP (2013)
2 Source: Recha et al. (2011).
3 Source: Gioto et al. (2016).
4 Source: MoALF (2013).

Agricultural context

Economic relevance of farming

Tharaka-Nithi County is located in the eastern part of Kenya. It borders the counties of Embu to the south and south-west, Meru to the north and north-east, Kirinyaga and Nyeri to the west, and Kitui to the east and south east. The county lies between latitudes 00^0 07' and 00^0 26' South and between longitudes 37^0 19' and 37^0 46' East. The total area of the county is 2,662.1 km^2 (GoK, 2013).

Agriculture is the mainstay of the county's economy. Both food and cash crops are grown in the county and approximately 80 percent of the population is engaged in agricultural activities and depends on agriculture for food, income and livelihoods. Agriculture contributes over 24 percent of the country's GDP, with the county receiving approximately KES8.7 billion from crops and KES1.6 billion from livestock and livestock products. The main food crops include maize, beans, cowpeas, sorghum, millets, green grams, bananas, and pigeon peas. The cash crops include coffee, tea, horticulture, and cotton. These include tea and coffee grown mainly in Maara and Chuka/Igamba ng'ombe constituencies.

Approximately 43,799 hectares of land are under food crops while cash crops cover 14,839 hectares. The county has a number of irrigation projects, including the Muringa Banana Irrigation Project in Maara which covers 1,444 hectares of land under traditional food and horticultural crops. The project has directly benefited 107,125 residents and the surrounding population through cheaper, all-year-round irrigation water. About 77 percent of the population in the county live in rural areas while 23 percent live in urban areas; reaffirming the importance of the rural economy (and agriculture) in the county (GoK, 2013).

The 2009 census placed the labor force at 202,887, representing 55.5 percent of the total population, with 62,785 (31 percent) of these being employed. This labor force was projected to increase to 234,311 by the year 2017, with 47.2 and 51.8 percent being males and females respectively. At present, a large proportion of the labor force comprises unskilled or semi–skilled men and women, mainly engaged in agricultural activities (GoK, 2014). In addition, approximately 81, 78, and 74 percent of male-, female-, and youth-headed households respectively, derive their income from crop-related activities. While 78, 56, and 52 percent of adult male-, adult female-, and youth-headed households derive their income from livestock-based activities. According to the 2014 ASDSP report 61 percent of youth-headed households earning their income from farm wages, thus indicating the importance of the agriculture sector for youth livelihoods and employment. In terms of earnings, the average income from on-farm activities is KES52,517; with KES34, 058 being earned from crops and KES26,960 from livestock activities. Overall, 83 percent of households derived their income from on-farm activities and seventy one (71) percent of households grow maize, with the average maize harvest of 187 kg per ha in the first season and 105 kg per ha in in the second season, out of which 72 and 82 percent was sold respectively.

Perennial crops, including coffee, tea, pawpaw, bananas, mangoes, and lemons which are grown mostly for sale. Twenty two (22) and four (4) percent of male and female-headed households grew coffee. Decision making on perennial crops is dominated by adult males. The mean value of total household income for the county was KES105,131 while the mean value of gross wealth was KES784,570. The annual per capita income was KES21,619 and per capita gross wealth was KES143,207. There was significant disparity in per capita incomes of household heads, with, about 72 percent of household heads being food insecure (GoK, 2014).

People and livelihoods

Tharaka Nithi County had a total population of 365,330, which was projected to increase to 478,570 in 2017, with 48 percent being male and 52 percent being female (Kenya Population and Housing Census (KPHC), 2009). Due to declining fertility rates among women, the county is at the onset of a transitional population structure where 0-14 year-olds, constituting 39 percent of the total population, are declining while the youthful population of 15-34-year-olds, constituting 33.3 percent of the total population is increasing (GoK, 2013).

The county is characterized by a high poverty level, which stands at 40 percent in the rural areas. The high incidence of poverty can be attributed to: unreliable rainfall; poor crop and animal husbandry practices; poor infrastructure; inaccessibility to credit facilities; poor marketing systems; natural disasters like frequent droughts, floods, and livestock and crop diseases; wildlife menace; and environmental degradation. Most of the county's population is literate with only 17 percent of the population unable to read and 13.2 percent not able to write, while those who can neither read nor write constitute 16.9 percent of the population (GoK, 2014).

Over 89 percent of the households rely on firewood and 8 percent use charcoal as their main source of household energy. Firewood is the most common cooking fuel with 90 percent of male-headed households and 87 percent of female-headed households using it. Only 8 percent use electricity as their main source of lighting (KNBS, 2013). Provision of clean sources of alternative energy will be critical in slowing down the felling of trees and extensive degradation.

The majority of the county's population access water from rivers, wells, springs, dams, and boreholes; although households in the county's urban areas largely use piped water. Forty six percent of residents use improved sources of water, with the rest relying on unimproved sources. There is a slight gender differential in the use of improved sources with 47 percent of male-headed households and 44 percent of female-headed households using such sources (KNBS, 2013). Distances to water source vary greatly with over 23 percent of the population spending over one hour to access clean water, clearly showing the need for more water sources to be established in the county both for domestic and productive use.

Value addition on livestock breeds and improved access to artificial insemination services have been crucial for farmer livelihoods. Fish are also important with catfish, tilapia, and trout being produced in the county. However, there is need for diversification, commercialisation, and intensification in crops, livestock, and fish production. Commercial trout fish farming, mostly in Nithi Thuci and Mutonga Rivers, is sponsored by the Tharaka Fisheries Initiative. Tharaka Nithi is also known for the community power generation scheme located at the Kamanyaki Great Falls Dam, which supports irrigation in some areas of the county. Tharaka Nithi fruit farmers also rely on processing of herbal medicine in the Meru Herbs Plant located along the Chokariga-Nkubu Road, with the plant bringing in over KES100 million to farmers between 2009 and 2013 (GoK, 2013).

The county has a malnutrition rate of 30 percent, higher than the national average of 20.9 percent; and far below the national target of 16.2 percent (KDHS, 2014). On average, individual members of the households (all the different age and gender groups) eat three meals in a day during the peak food availability season. In the lean season, children have three meals while others have two meals per day. Eighty-two percent of the households report not having enough food to meet their needs. Food insecurity is highest among female-headed households at 85 percent compared to 83 percent and 79 percent for male- and youth-headed households respectively (GoK, 2014). The factors affecting food insecurity include poor distribution of rainfall, high food prices, poor infrastructure, communal land tenure system, low adoption of drought-tolerant crops, and low use of fertilisers and certified seeds. These factors impact negatively on overall food security, leading to poor household food consumption levels. Retail and wholesale businesses are becoming more prominent in the urban areas of the County, and these help to promote development and economic growth in the county.

Agricultural activities

Tharaka Nithi County has two main ecological zones namely The Highlands (upper zone) comprising Maara and Chuka, which receive adequate rainfall for agriculture; and The Semi-Arid Zone (lower zone) covering Tharaka North and Tharaka South and Igamba Ng'ombe sub counties and receives less than 700 mm of rainfall per annum, making it largely suitable for livestock rather than crop production. Tharaka Nithi is generally a low land, with an altitude ranging between 250 and 1500 m. The main agro-ecological zones are: Upper Midland UM2, 3 and 4; Lower Midland 4 (LM 4), Lower Midland 5 (LM5), Intermediate Lowland Zone 5 (IL5); and Intermediate Lowland Zone 6 (IL6). The AEZ IL5 and IL6 cover the north-eastern and southern tip of the county; they are the driest agro-ecological zones with agro-pastoralism as the main livelihood. Zone LM4 covers the western part of the county and is characterised by mixed farming (near Tunyai) and rain-fed cropping in the north-west. The Maara and Meru South/ Chuka sub-counties in the west and northwest of the county are predominately upper midlands, receiving moderate to high rainfall. Based on these agroecological zones the county can be divided into 3 livelihood zones: mixed farming (MF) with 43 percent of the population, marginal mixed farming (MMF) with 35 percent, and rain-fed cropping (RFC) with 13 percent.

Millet, sorghum, and green grams are the major crops grown in the Marginal Mixed Farming Livelihood Zone. Maize, cowpeas, and green grams are grown in the Mixed Farming and Rain-fed Cropping Livelihood Zones. Green grams are a main source of income in all the livelihoods while millet and maize are the major food crops. The major annual crops grown include maize, cowpeas, green grams, pearl millet, sorghum, and pigeon peas. Most people in Tharaka Nithi County practice mixed farming, combining goat and cattle herding with crop cultivation. Crop cultivation has grown in economic importance relative to livestock herding over the past 30 years. The dominant staple crops in the county are drought-resistant sorghum,

Livelihoods and agriculture in Tharaka Nithi

Demographics

1% Of Kenya´s population

399,735 inhabitants

77% Live in rural areas

51% 49%

Farming

County´s farming area

1,450 km² 54%

38% of the population employed in agriculture production

62% of farmers have title deeds

ND are women

Farming activities

Food crops

Cash crops

12%

4%

Of county´s agricultural land

Livestock

ND Group ranches

ND Company ranches

Access to basic needs

35% of the population lives in **absolute poverty**

Potable water	8%
Electricity for cooking	ND
Electricity for lighting	2%
Education (youth literacy rate)	87%

Tharaka Nithi

Food security

40% of the population suffers from **food poverty**

ND of household **income spent on food**

ND People **undernourished**

ND Children **stunted**

ND Children **wasted**

Farming inputs

Water uses

ND ND ND

Fertilizer types (% of households)

NPK

51% Organic manure

29% Planting fertiliser

21% Top dress fertiliser

Pesticide types (% of households)

49% Field pesticides

62% Storage Pesticides

32% Herbicide

ND: No data

Infographic based on data from the County Integrated Development Plan (GoK, 2013), the Agricultural Sector Development Support Program (GoK, 2014), and Kenya National Bureau of Statistics (KNBS, 2015)

bulrush millet, green grams and cowpeas, which perform well in the prevailing semi-arid conditions. Maize is widely grown in the wetter midland zone. Katumani Composite Maize is an early maturing variety that most Tharaka Nithi farmers plant at elevations greater than 900 meters (agro-ecological zone LM 4).

Below 900 meters, farmers rely mostly on livestock rearing. Livestock keeping, especially that of indigenous breeds, is the second most important source of livelihood in the county. It provides up to 95 percent of food and income in the marginal mixed farming zone and 50 percent to food and income in the rain fed areas. The livestock species kept in these zones are mainly goats, sheep, cattle, and poultry. The main livestock in the county include Friesian, Guernsey, and Ayrshire breeds of dairy cattle; indigenous zebu cattle; sheep; goats; and chicken. The development of dairy farming is on the increase, hence the expansion of the livestock market across the county. Goats, cattle, and poultry are kept mainly by agro-pastoralist populations for milk, meat, eggs and hides. Milk is produced by local cattle, crossbred cattle, exotic cattle, local goats, and exotic dairy goats. The sources of meat are mainly local and dual purpose cattle, local goats, sheep, indigenous chicken, broiler chicken, and rabbits (GoK, 2014).

The county's location on the eastern side of Mount Kenya, combines with latitude, the Inter Tropical Convergence Zone (ITCZ), ENSO, sea surface temperatures and tropical cyclones (Odingo et al., 2002) to influence rainfall variability. The County has a bi-modal rainfall pattern, with the long rains in March-April-May (MAM) and the short rains in October-November-December (Shisanya, 1996). Farmers practicing rain-fed agriculture and agro-pastoralism rely on the October-November-December (OND) rains; which are considered reliable and can be predicted with a reasonable degree of accuracy (Cooper et al., 2008; Hansen and Indeje, 2004). The climate in the county is favorable for cultivation of tea, coffee, maize, cowpeas, pigeon peas, tobacco, and a variety of other food crops (GoK, 2013). The county is also well endowed with several permanent rivers with great potential for irrigation and power generation including: Thuuci, Ruguti, Naka, Tungu, Nithi, South and North Maara, Kathiita, Mutonga, Kithinu, Ura, Thingithu, Thanantu, Thangatha, and Kuuru. The county also has considerable ground water resources, springs and streams, earth and sand dams, and rainwater and rock catchments. A number of wetlands are found in the lower-altitude areas. The warm climate, fertile soils, and plentiful surface and underground water give the county an advantage for irrigated agriculture.

In the County, 33 percent of farmers do not have land title or certificates. Most of the county residents are small-scale farmers with an average land holding of 2.9 hectares, mostly used for food and cash crop farming. The average landholding for the large-scale farmers was 6.7 hectares. The slow adjudication of land, boundary disputes, and conflicts over grazing land are a source of uncertainty in land ownership rights (GoK, 2013), particularly in the Meru sub-county. This limits farmers' capacity to invest in resilience building initiatives.

The types of farm machinery used are tractors, ox–ploughs, pumps, threshers, incubators, and chaff cutters. About 47 percent of households use farm machinery in their agricultural activities; mostly for land preparation (70 percent), harrowing (11 percent), planting (6 percent), chopping livestock feed (5 percent), and pumping water (4 percent). Market information was the most common information services used by households.

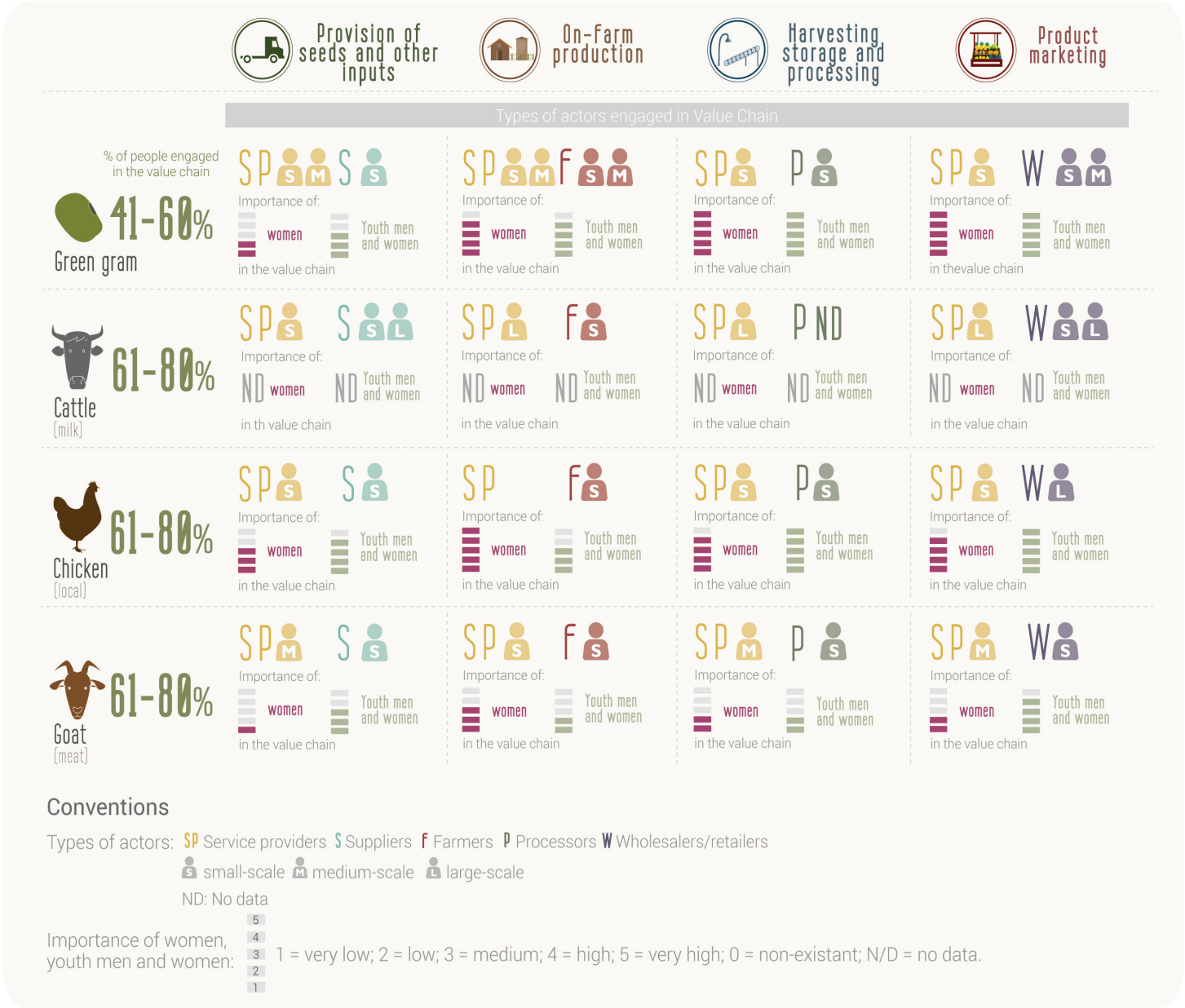
Agricultural value chain commodities

A broad diversity of agricultural commodities are grown in the county. Of these, various value chains have been prioritised as being strategic for the county as indicated in the County Integrated Development Plan (CIDP) and the Agriculture Sector Development Support Programme (ASDSP) as well as by government institutions such as the Kenya Agricultural and Livestock Research Organization (KALRO). For the development of this County Climate Risk Profile, four major value chain commodities (VCCs) were selected for in-depth analysis based on: prioritisation in county frameworks and programmes; economic value (KES/bag or KES/livestock or KES/unit livestock product)[5]; resilience to current weather variability and future climate change[6]; and a number of economically active people engaged in the commodity's value chain (including vulnerable groups, women, youth, and the poor). The VCCs selected are local poultry, cattle (milk), goat (meat), and green grams.

5 As stated in the 2015 Economic Review of Agriculture (ERA)

6 Resilience is as defined in IPCC (2012); where we consider the general risks posed by climate change in the county. Value chains that are perceived to survive the local conditions under the current production systems holding other things constant (including variations in technology adoption rates among farmers and pastoralists) are considered more resilient.

Agricultural value chain commodities in Tharaka Nithi



Chicken (local)

The poultry industry in Kenya has, over the years, progressed to become one of the most important livestock enterprises. Local chicken is predominantly found in the rural areas where they play a key role in enhancing household food security. The sector is constrained by low quality of feeds, low productivity, fluctuations in production and demand levels, poor marketing infrastructure, diseases, and inadequate research and development. In 2014, there were 611,271 birds in the county, with an annual poultry meat production estimated at 268,994 kg and valued at approximately KES72 million.

Local poultry keeping is low-input and often does not require supplemental feeding where the chickens are left to scavenge for food. Chicken-rearing is traditionally considered a women's activity, but provides assets that benefit the whole household. The involvement of women and youth is high at all the four stages of the value chain. The main production systems practiced are free range, semi intensive, and intensive. The semi-intensive and intensive systems are practiced for commercial purposes. The free-range system is practiced everywhere but is most common in Tharaka North and South sub-County. The semi-intensive system is practiced in Meru South sub-County while

the intensive system is practiced in Maara sub-County. The free-range system is the most preferred; the chicken produce quality meat and eggs.

About 61-80 percent of the households are involved in the local poultry value chain. Farmers mainly engage in feeding, cleaning, vaccination, de-worming, slaughtering, processing, collection, transportation, and wholesaling, although this is largely at small scale. Other actors involved in the value chain include brokers and other traders, rural retailers, rural wholesalers, urban retailers, and urban wholesalers. Service providers in the value chain include veterinarians, transporters, millers, and feed traders. Women sell both eggs and live chicken at the farm gates to buyers, who are usually men. It is men who act as primary and secondary collectors as well as sales persons at the market. However, a number of women own market stands but employ a young man to assist with slaughtering. The local chickens are a ready source of income for women. They serve as virtual 'bank accounts' and help women to improve family nutrition and food security. Improvements in chicken management have other benefits, such as manure for use in the garden. Chicken keeping also promotes crop diversification to produce supplementary chicken feed.

The local chicken discussed in this document are the indigenous breeds. The commercially improved local chickens available from suppliers such as KALRO Naivasha are also recommended. Such improved chicken are usually dual purpose (egg and meat), laying eggs from as early as 4.5 months of age, producing 180-280 eggs in a lifetime, while the males can attain 2 kg live-weight in about 5 months. The high productivity will result in reduced greenhouse gas (GHG) emissions per unit of product. Feeding of local chicken is important in order to increase production of meat and eggs. A lack of feed and water will reduce resistance to diseases and parasites and lead to mortality. To attain a balanced diet, it is recommended that in addition to scavenging, chicken need supplementation containing energy, protein, vitamins, minerals, and water. The need for feed will change depending on the age and status (chicken, grower, egg layer, broody hen) of the bird. The cheapest way to supplement a poultry diet is to use local resources. Formulations of high quality poultry feed based on Soya SB 19 and SB9 are available, and have high crude protein (38 percent CP); they are therefore suitable for use in non-ruminant feeds.

Introducing one cock for every 10 hens every 2 years, helps avoid inbreeding. Since fertile eggs grow slowly, eggs that are more than 14 days old should not be used for hatching. Improved management increases survival rates from 2 to 6. Other breeding management strategies include serial hatching, synchronised hatching, and artificial incubation.

Pest and disease management is important in local chicken farming. Main diseases include: Newcastle Disease, pullorum, coccidiosis and fowl typhoid. Vaccination technologies include; The Thermostable New Castle Disease vaccine[7] – Avivax I, Strategic worm control for local chicken[8], up scaling McMaster Egg floatation technique (a technology used for detecting worm infestation in animals especially for coccidiosis diagnosis in poultry) and Computerised detection of Anthelmintic resistance[9].

Green grams

Green grams are an important food and commercial crop in semi-arid areas of Kenya and are heat and drought tolerant; having an optimum temperature range of 27-30 °C. It is an erect annual plant that grows to a height of 60-70 cm. Green grams are often cultivated in rotation or in relay with cereals and consumed as whole seeds boiled with cereals. They are considered an important income-generating crop by over 60 percent of households. It is also considered a high-value traditional crop (HVTC) or "orphan crop" adapted to the extreme soil and climatic conditions of the county; it is suitable for the agro-ecology and socio-economic conditions of semi-arid regions of the lower side of the county which include: Tharaka North, Tharaka South, and Meru South, particularly Igamba Ng'ombe area. Generally, farmers in these areas grow both improved (60%) and local varieties. The farming systems include small-scale pure stands common in Kajuki and Kathwana and Marimanti; small-scale intercropping with maize, sorghum, and millet predominant in Tunyai and Ciakariga; and the medium-pure stand in Gaciongo and Gatunga area in Tharaka North.

Production of green grams was noted to be increasing; largely attributed to market assurance,

7 Where there is high disease prevalence, Vaccination and isolation of healthy birds from sick ones and proper disposal of dead birds can prevent diseases. Vaccination for indigenous chicken in a free-range system will depend on age, disease incidence, severity and status of endemic diseases. Improved sanitation, eggs and nest fumigation using formal dehyde pellets in the nest can prevent it. A broad-spectrum antibiotic such as sulphur drugs controls infections.

8 This Involves application of anthelmintics when worm infestation risk is high. It is reliant on climatic conditions. The strategy reduces selection pressure for anthelmintic resistance.

9 It is a computerized technique for detecting anthelminthic resistance. A computer application is used to calculate the egg reduction advice on drug usage and Salmonella screening technique. A blood drop is obtained from the wattle of the chicken and placed on a slide and mixed with stained salmonella antigen. Agglutination indicates that the chicken is infected with Salmonella spp. Which causes heavy mortality in chickens and reduces productivity.

with an associated increasing trend in adoption of improved varieties particularly NS26 (Nylon) green grams. This variety is mainly used as food by the farming households; although it is also sold as a source of income. KS20 (Angle) variety has a higher demand than NS26, and is produced exclusively by smallholders, 70 percent of whom consider it an important income crop. There is low involvement by farmers in input supply, attributed to low access to land, which is an impediment especially for youth and women in agriculture in the county.

Green grams are affected by various diseases whose incidence is influenced by management practices such as late planting, use of infected seeds, and other cultural practices such as intercropping with cereals and various other crops. Clear sanitation and proper plant protection measures must be followed in order to avoid infestation by pests and diseases. Some of the notable pests are thrips, aphids, pod borers, white flies, caterpillars, foliage beetle, and weevils. The main diseases are powdery mildew, yellow mosaic virus, and rust. To control pests, there is need to apply pesticides such as Thiodan, Duduthrin, Thiodan, Bestox, Actellic super, and Sherpa plus. Disease control requires application of chemicals such as Score, Thiovit jet, Benomyl, Copper oxychloride, and Ortiva.

In terms of post-harvest management, drying after threshing and winnowing is crucial. Threshed seed should be dried on mats, plastic sheets or wire mesh trays raised on a platform. Green grams with about 12 percent moisture content can be stored in regular grain bins that have been fumigated to control bean weevils. If beans are higher in moisture (above 12 percent), they can be sun dried. The store should be well aerated, leak proof, and damp proof. The grains should be dusted using different formulations of storage dusts at rates of 50 g per 90-kg bag. Packing should be in airtight bins, silos, or hermetic bags, however ordinary 90-kg polythene bags can also be used.

Overall approximately 41-60 percent of the households are engaged in the green gram value chain, with a high proportion of these being women and youth working in on farm production and marketing. This makes the crop extremely important for household livelihoods and food security. Households and farmers are mainly engaged in land preparation, weeding, harvesting and spraying, value addition (storing, transporting, and bulking), and marketing. In terms of input supply and marketing, brokers, rural retailers, rural wholesalers, urban retailers, urban wholesalers, extension officers, and transporters play a crucial role. Various NGOs and development partners such USAID/KAVES, RIDEP, GRADIF-Kenya, Caritas, KMD and KALRO provide seeds, climate- related information, as well as providing extension services to the farmers on input utilisation, good agronomic practices, and storage. A key area for farmer capacity building in green gram production includes appropriate dryland farming techniques and business management skills.

Cattle (milk)

The dairy sub-sector in Kenya is projected as the most developed in sub-Saharan Africa and contributes 3.5 percent of the country's GDP. Many of the stakeholders in the dairy sector are subsistence and/or small scale farmers; and despite the plausible performance, the dairy industry is bedeviled by several challenges including inadequate feed, prevalence of diseases, unavailability of quality replacement stock, low adoption of technologies, high cost of farm inputs, and low value addition among dairy producers. Eighty percent of the households in Tharaka Nithi keep dairy cows for food and income, with the livestock department estimating that there are 46,188 dairy cattle in the county which produced approximately 34 million liters of milk in 2016. The main breeds kept include Friesian, Guernsey, and Ayrshire breeds. .

The main sources of milk in the county are indigenous, crossbreed, and exotic cattle. They give on average 2, 6, and 11 liters of milk per animal per day respectively. According to the ASDSP 2014 household survey, male- and youth-headed households produced an average of 2 liters of milk per indigenous cow per day, while female-headed households produced 1 liter. Exotic cattle breeds are solely in the domain of male-headed households, and have a production of 8 liters of milk per cow per day in the dry season and 11 liters in the wet season. Cross breed cattle are kept by both men and women and have a productivity of 5 liters per cow per day for both male- and female-headed households. Exotic dairy cattle are solely in the domain of male-headed households and produce 8 and 11 liters of milk per cow per day during the dry and wet seasons respectively. Male-headed households still dominate in milk production across all the dairy animal types.

Zero grazing and semi zero grazing are the major production systems practiced in the county. The zero grazing system is mostly practiced in the highlands, notably in Chuka and Maara areas; the semi- zero grazing system is practiced in the Igamba Ng'ombe region as well as in some parts of Tharaka, mainly in Gatunga and Marimanti regions.

About 61–80 percent of households in the County are engaged in the value chain. Engagement of women and youth in this value chain is medium, with women being heavily involved in the on-farm production stage. The youth are heavily involved in the input

and marketing stages. The key actors in the value chain are input suppliers, technical service providers, traders, transporters, processors, and retailers. The input suppliers include agro-vet dealers located in the nearby shopping centers and major towns (Chuka, Chogoria, and Marimanti). They provide feed and dairy equipment at both large and medium scale. Animal health service providers (extension workers) provide AI and vaccination services at small scale. The county government also plays an important role in providing extension services and regulating the AI service providers. Farmers, who are mostly small scale, use family labor and local casual labor in on-farm production activities. Milk is the sole livestock product realised and is marketed through contractual arrangements.

A number of milk cooling plants have been established in Chuka Igamba Ng'ombe and Maara through funding by the Constituency Development Fund. The Kenya Dairy Board (KDB) set up new regulations that make it illegal for milk vendors to sell milk without a license; they are also ensuring that the milk sold is pasteurised. Thus, the board in collaboration with the Ministry of Agriculture, Livestock, and Fisheries conduct routine product sampling, testing, and follow-ups to ensure that the vendors adhere to the acceptable hygiene standards. Processed dairy products are retailed by supermarkets, kiosks, and hawkers in all urban centers. While there is no milk processing in the county, the Meru Central Dairy Farmers Cooperative Union (MCDFCU) collects milk from some small-scale farmers in Maara, which borders Meru County. The service providers for finance, accounting, and business development skills, insurance, quality testing and certification, and research play a critical role in the development of the dairy value chain. They involve various NGO's, Government Agencies (MOLF and KDB), self-help groups and hawkers who play a big role in marketing at both large and small scale.

Dairy milk technologies, innovations, and management practices necessitate keeping of certain breeds such as Sahiwal, Boran, and Friesian/Sahiwal crosses. This requires breeding and breed management, which in turn entails germplasm development and breed improvement through Assisted Reproduction Technology (ART) and AI. Other innovations and management strategies include: use of EM-Fortified milk replacer diets, homemade dairy rations and Lupin seed-based feed supplements, cultivation of disease-tolerant Napier grass varieties and clones, alley cropping and intercropping herbaceous legumes with Napier/fodder trees, feed conservation - conserving Napier grass with legume forage and an energy source for dry season feeding, preparing a dry season feed package such as a residue-based cereal crop, and growing fodder shrubs and herbaceous legumes through agro-forestry systems.

Animal health management is important because it ensures proper nutrition, treatment, and control of diseases. This includes regular dipping to control ticks and immunisation (particularly against East Coast fever (ECF), Foot and Mouth disease, Black quarter, Anthrax, and also Lumpy Skin Disease (LSD)). Deworming of calves and cows is recommended before the onset of the rains. Other health management strategies include use of Medicated Molasses Urea Mineral Blocks (MUMBs). The thick blood and thin blood smear technique is used for detecting trypanosomes and tick-borne diseases. Trypanosomes lead to acute or chronic weight losses and high mortalities.

Milk contamination surveillance for cattle is necessary for checking cleanliness in cattle milk. A rapid diagnostic kit is required for detecting aflatoxin, antibiotics, and drug residues in milk. The rapid serum agglutination test for ruminants is a tool used for detecting antibiotic resistance in cattle. Zero-grazing for manure management and installation of biogas units is also important for reducing methane and nitrous oxide emissions and also provides energy for household use. The slurry from the digester unit can also be used as fertilizer. Finally, water harvesting and storage for livestock use is paramount.

Goat (meat)

Goats are versatile and have adaptable feeding habits. They are therefore less affected by weather hazards and climate change; making them important especially given that climate change is expected to be more severe in the pastoral and agro-pastoral production systems in the low rainfall areas. At household level, goats are useful for wealth creation, insurance, trade, as an easy source of cash, and as a recovery strategy after drought. Goats contribute about 14 percent of total annual red meat produced in Kenya. Potential exists for exporting goat meat. However, competitiveness is low because the quality demanded is hardly attainable. On the African market, competitiveness in the region may be eroded by freight costs. The EU market maintains stringent sanitary and zoo sanitary (SZS) standards in relation to diseases like FMD and goat pox.

Over 80 percent of the people are engaged in this value chain, with at least every household having a goat. Free range, mixed or semi enclosed (partly free range and partly enclosed) methods and the enclosed method are the major goat production systems practiced in the county. The dominant system is the free range system. Farmers keep more than 50 goats in over 4 hectares of land. According to MOALF, the quantity

of goat meat produced in 2016 was 1,978,200 kg, valued at KES 316,512,000. Women and youth are involved in the four stages of the value chain. Their involvement is medium at the on-farm production stage and very low at the input stage. However, the youth are heavily involved at the product marketing stage; their involvement is medium at the input stage.

The proposed goat meat technologies, innovations, and management practices entail having a preferred breed. The main preferred breeds are the Small East African and the Galla goat. Breeding and breed management entail castration. Improved livestock health management practices are necessary in controlling mortality. Use of a mobile house for kids to control mortality is important because it reduces ecto-parasite-related mortality commonly witnessed during periods of drought and other prolonged dry spells. Such periods bring about a high build-up of fleas and lice. Climate risks have caused shifts in disease and pest borders, thus increasing the risk of disease transmission. Therefore, formulation and promotion of an integrated disease control package for ruminants includes promotion of an ECF vaccine. The thermostable Peste des Petits Ruminants (PPR) vaccine remains viable with high antibody titres at 37°C for 7-14 days. The current vaccine is cold-chain dependent, making uptake low. PPR occurs in ASALs and is not treatable; it causes heavy economic losses. The thermostable Routine vaccination against CCPP, Sheep and Goat Pox as well as regular vector control is recommended for livestock health management. Other health management practices include: non-conventional deworming, which means deworming using a pumpkin seed extract, rapid detection, and early warning and response through sentinel screening. EMPRES-promoted principles and tools can be used for other climate-related, vector-borne diseases. The thick blood and thin blood smear technique is used for detecting trypanosomes and tick-borne diseases. Trypanosomes lead to acute or chronic weight losses and high mortalities.

Nutrition management is necessary; it may include provision of medicated feed blocks to help in the control of in goats. Blocks are rich in proteins; minerals in the block improve digestibility of roughages since feed is a challenge in the ASALs. This challenge has been complicated by climate risks. This in turn aids in rapid weight gain. Fodder production and conservation is necessary because it supports livestock in drought periods, reducing goat mortality, and can also be used to fatten goats for sale. Annual rather than perennial grasses make better hay if harvested early in the dry season. Other feed materials that can be bulked include crop residues and legumes planted as fodder crops.

Agricultural sector challenges

The major challenges to agricultural production in the county include: the effects of weather variability and climate change with shifts in planting time, occurrence of moisture stress during the crop growing period and heavy rains during harvesting; high post-harvest losses; poor market access due to poor road networks; high illiteracy levels among farmers, lack of good storage and value addition facilities; exploitation of producers by middlemen; lack of large-scale manufacturing industries to add value to agricultural produce; rampant tree felling, lack of education among farmers on the good agricultural practices, low adoption of improved agricultural technologies, and expensive farm inputs.

Poverty levels affect the capacity of people to invest in resilience and productivity increasing practices. Illiteracy limits farmer ability to access information and technologies on land use. High unemployment rates and low involvement of youth in agriculture has also affected agricultural productivity. The effect is expected to impact negatively on the economy of the county, leading to reduced crop and livestock productivity, famine, malnutrition, high livestock mortality, and loss of income for community members.

There is limited use of inputs, attributed to high prices, insufficient income, distance to input markets, and lack of availability of inputs at the right time. Farmers are generally not able to afford the optimum amounts of inputs, technology, agricultural information, and financial services.

Poor road and market infrastructure (modern abattoirs and livestock holding grounds) in the county leads to inflated prices of food and other basic commodities as a result of high transportation costs, which also undermines an effective supply chain for highly perishable livestock products such as milk and meat. Most market centers that used to serve as sales outlets for farmers have collapsed, leaving Chogoria, Marimanti, and Chuka as the main market centers serving the entire county.

The county lacks agro-based industries that add value to farm and livestock products and enables farmers to fetch good market prices. Lack of capacity to undertake value addition and lack of storage facilities have forced farmers to sell their raw products to middlemen at very low prices.

Agricultural production has varied over the years due to erratic and unreliable rainfall. The increasing temperatures and low rainfall coupled with poor soil fertility impact negatively on productivity of the various crops. Crops and livestock have become

more vulnerable to pest attacks and diseases; leading to reduced crop yields, poor quality produce, and sometimes total crop failure. Varied production also presents a challenge for marketing.

The tea and coffee sectors have been affected greatly due to delayed payments to farmers; most farmers have therefore switched to banana, sorghum, green gram and dairy farming. Some areas in the county are very dry so there is a need for an irrigation scheme that can help farmers to boost food production. Moreover, several interventions geared towards improving agricultural productivity such as construction of dams for irrigation and proper land use management have been affected by insufficient funding.

Climate change-related risks and vulnerabilities

Climate change and variability: historic and future trends

Tharaka Nithi County has mean annual temperatures that range from below 21°C in the west to above 25°C in the east, this variation being primarily due to an east to west pattern of rising altitude. Similarly, rainfall in the county exhibits a strong east-west gradient of increasing rainfall. Most of the western part of the county receives average rainfall of 1000- 1250 mm annually; a small pocket in Chogoria Forest receives as much as 2200 mm annually. On the other hand, most of the eastern part of the county receives an average of 750-1000 mm annually, except for a small south eastern corridor where rainfall is 500 - 750 mm. In general, the highland areas in the west have higher, more reliable rainfall and lower temperatures while the lowland areas in the east have lower, less reliable rainfall and higher temperatures. Given the large range of temperature and rainfall in the county, the agricultural hazards and risks are similarly broad. They include dry spells and heat stress as well as changes in rainfall season dates and duration along with incidences of flooding. These hazards occasionally result in crop failure; reduction in pasture availability with impacts on livestock weight and output (particularly milk); and damage to infrastructure among others.

Analysis of historical temperature trends in the county over 25 years (1981 to 2005), show that first and second season mean temperatures have increased by approximately 0.7 and 0.5°C respectively. These increases in temperature have resulted in a moderate increase in heat stress days in both seasons. On the other hand, precipitation trends based on analysis over a 35-year period (1981-2015) showed that average first season rainfall is decreasing moderately while average second season rainfall is increasing slightly. The reduction in first season rainfall has resulted in an increase in the occurrence of drought stress over the same period. However, the changes in second season rainfall and temperature have not had an effect on extremes; flash floods and drought stress are therefore likely to remain relatively constant over the period under consideration.

Climate projections for the period 2021-2065 based on two representative concentration pathways (RCPs[10]) indicate that under both scenarios and for both seasons, temperatures are expected to increase. Under the low emissions scenario, rainfall in both seasons is expected to increase. This will result in a reduction in the length of dry spells[11] and the number of days with moisture stress[12]. In contrast, in the high emissions scenario, it is expected that there will be a slight decrease in the intensity of rains resulting in more days with moisture stress although drought stress will decrease. Although season length is expected to increase for both seasons regardless of the emissions scenario, under the high emissions scenario the seasons are expected to start later; under the low emissions scenario, the seasons are expected to start earlier. The projections under the two GHG emissions scenarios show some differences. However, both indicate the likelihood of increased temperatures, changes in onset and duration of season, and changes in the occurrence of drought and moisture stress. These changes hence represent the main adaptation considerations for the county.

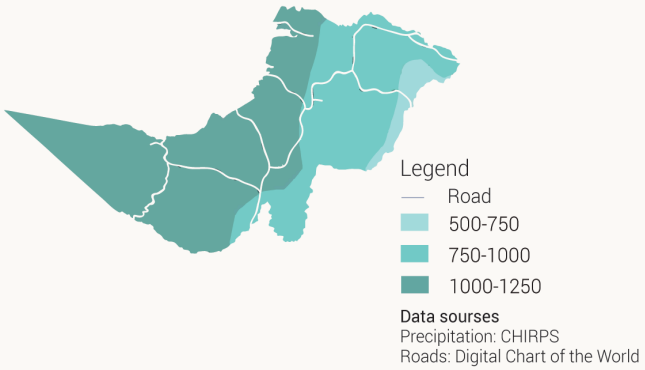
10 The two RCPs, RCP2.6 and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6 and +8.5 W/m2, respectively). The pathways are used for climate modelling and research. They describe two possible climate futures, considered possible depending on how much greenhouse gases are emitted in the years to come. RCP 2.6 assumes that global annual GHG emissions (measured in CO2-equivalents) peak between 2010 and 2020, with emissions declining substantially thereafter. In RCP 8.5, emissions continue to rise throughout the 21st century

11 Maximum number of consecutive dry days (precipitation < 1 mm day-1)

12 Number of days with ratio of actual to potential evapotranspiration ratio below 0.5

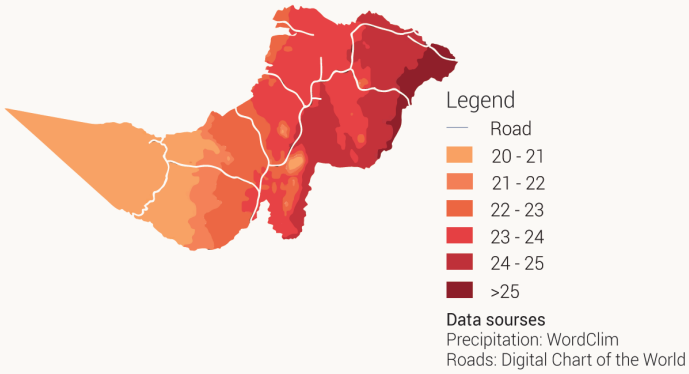
Past and future impacts of climate hazards in Tharaka Nithi

Historical annual mean precipitation (mm/year)



Data sourses
Precipitation: CHIRPS
Roads: Digital Chart of the World

Historical annual mean temperature (°C)



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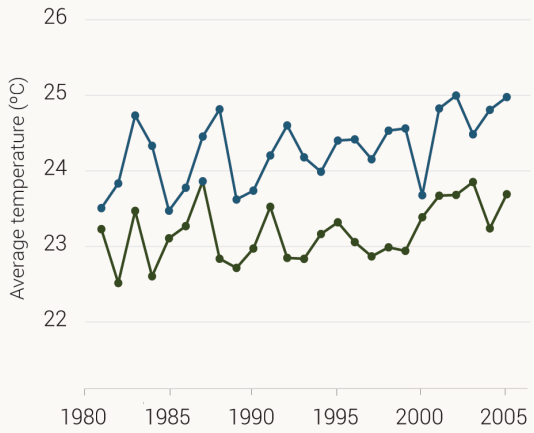
Precipitation: WordClim
Roads: Digital Chart of the World

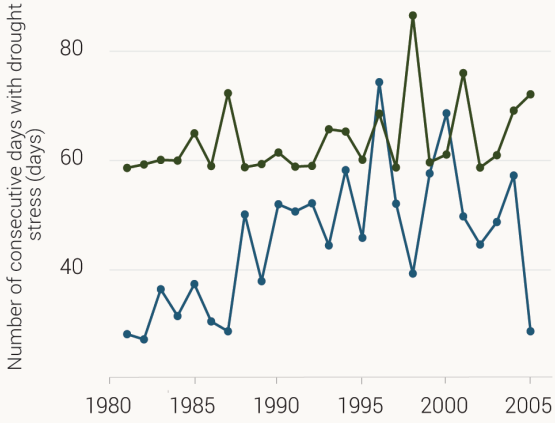
Heat stress hazards

Moisture stress hazards

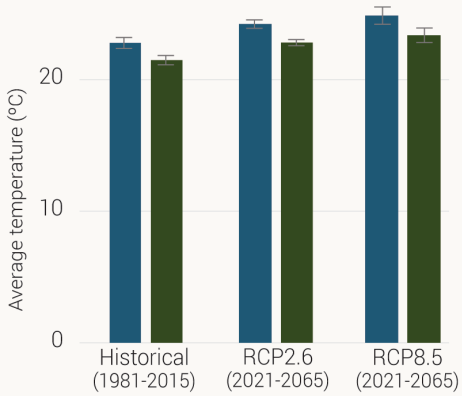
Historical extreme heat stress events



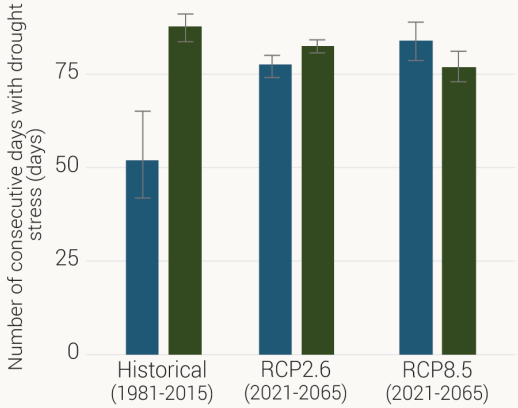
Historical extreme moisture stress events



Historical and expected extreme heat stress events



Historical and expected extreme moisture stress events



January - June July - December

Climate Perceptions by the farmers

Farmers interviewed indicated that they were not familiar with the science behind climate change, but that they had experienced a remarkable variation in the weather and climatic conditions in Tharaka Nithi County over the years as well as noticing changes related to increased soil degradation and water availability. Farmers reported rainfall changes and drought occurrence over the past 10-20 years; the drought events include severe droughts in 1990 and 1995, and a series of mild to severe drought events between 2000 and 2008/9. Heavy rainfall events were also cited as having occurred in 1992/3 and 1997/8.

Farmers also indicated that they had witnessed exceptionally dry weather and landslides; these ultimately lead to poor crop yields and low livestock production. Farmers say the weather has become more unpredictable than in the past, mostly as a consequence of human activities and land degradation. The farmers reported that the climate change problem was aggravated by deforestation, linked to capacity of the forest department. Notable changes due to climate change cited are the drying up of Rivers Thanantu and Thingitu in Tharaka Constituency. Rivers have been affected by a decrease in rainfall and human encroachment. Water and food availability were said to have declined in line with trends in rainfall and water availability in particular the 1997/98 El Niño rains. Changes and variations in climate have posed important economic and social consequences. Farmers reported that declining incomes were connected to the unreliable rainfall patterns, which were considered to have been declining steadily since 1997. Other issues that came about in regard to climate change were strong winds that caused destruction, massive erosion that led to soil infertility, increased incidence of pests and diseases, and poor harvests. The notable impacts reported were lack of food, death of livestock, malnutrition, and reduced income.

Climate vulnerabilities across agriculture value chain commodities

Climate change and variation pose serious threats to the value chain commodities prioritised for analysis in this study. These affect the prioritised value chain commodities differently as shown in the following discussion.

Chicken (local)

Although the value chain is perceived to be resilient to climate hazards, it was reported that moisture stress and increase in temperatures affect local chicken negatively. Notable effects range from low growth rate of the chicks to high demand for feeds and vaccines. The increase in temperatures is already affecting the semi-arid or lower zones of the county, mainly Tharaka North, South and the lower parts of Igamba Ng'ombe, which include Kathwana and Kajuki; it is also affecting Magutuni area in Maara. The effects include an increase in prices of poultry and vaccines; prices of extension services have also increased. At the on farm production stage, effects of moisture stress on the value chain are reflected in slow growth rate and an increase in diseases. An increase in temperature at the input stage stresses day-old chicks, often resulting in high mortality. It increases the cost of feed and sometimes spoils vaccines. Men and women in the low-income category are most affected, as they depend heavily on this value chain.

Green grams

The two climate hazards affecting the green gram value chain are moisture stress and an increase in temperature. Moisture stress affects the western parts of the lower zone of Tharaka areas including Tunyai. Increases in temperature mainly affect the eastern parts of lower Tharaka and Igamba Ng'ombe, which include Gaciongo, Gatunga, Marimanti, Ciakariga, Kathwana and Kajuki areas. Green grams grown during a dry spell are normally of low quality due to poor germination, flower abortion, and withering. The consequences include low production, leading to food insecurity at household level, while the poor quality of the harvest decreases its marketability. Other challenges associated with moisture stress and high temperatures include: limited availability and increased costs of inputs such as seeds and fertilisers, crop failure, reduced access to extension services, reduced mobility due to heat stress, and increased crop infestation by pests. Moreover, heat stress affects land preparation activities; only limited land sizes are prepared as prevailing conditions are not favorable for production of green gram. Because the soil is hardened, more labor is required to work it, hence costs of land preparation rise. All gender groups are affected by this hazard, however women are more susceptible to increased labour requirements.

Cattle (milk)

The cattle milk value chain is affected highly by increases in temperature and moisture stress. The areas affected the most by moisture stress are in the upper zones of the county, which include Chuka, Mpukoni, Chogoria, and Ngeru areas. Most of the lower zone, which is semi-arid, is affected by increases in temperature; the zone comprises Tharaka North and South and lower areas of Chuka Igamba Ng'ombe. Moisture stress and increases in temperature are the major causes of low

cattle milk production in the county. These hazards lead to reduced pasture for the animals; poor body condition and low milk production. Milk production is more highly to high temperatures as both milk output is reduced, while the milk is produced is often spoilt before reaching the market. Increases in livestock diseases such as East Coast Fever (ECF) and pests including ticks also occur during hot dry periods, with some tick-borne diseases often leading to death. Low milk production affects the food security of farmers, especially pastoralists. Transporters are also affected as the demand for transportation decreases.

Goat (meat)

In the goat (meat) value chain, moisture stress and increase in temperatures have been identified as the most problematic hazards. The areas affected by moisture stress are the upper zones, mainly Chogoria and Chuka, all the way to Itugururu. Some areas in the lower zones like Tunyai and Mukothima are also affected. Increases in temperature affect the lower parts of the county from Gaciongo, Gatunga, Marimanti, Ciakariga, Kathwana, and Kajuki. As a result of this hazard, goats feed poorly and become vulnerable to diseases. Moreover, production costs rise due to the high demand for inputs such as vaccines and veterinary services. The risk of losing livestock significantly increases especially during feeding and transportation due to dehydration. As a result, farmers sell their stock at low prices partly due to weight loss and market saturation since every pastoralist will be trying to offload their goats and avoid losses. Poorer members of the community, especially those with smaller livestock holdings and less-developed social support networks are in general more affected by these climate hazards.

Adaptation to climate change and variability

Following the adverse impacts of the climate hazards identified along the different value chains, adoption of measures that enhance resilience of the value chains is paramount. Some of the adaptation strategies Tharaka Nithi farmers are using to cope with climate change and variation are specific to certain value chains whereas others cut across value chains. For crop farmers, these include improved drought-resistant crop varieties, fast-growing and early-maturing crop varieties and rain water harvesting, conservation agriculture, crop rotation and intercropping, afforestation, and irrigation. For livestock keepers, these include fodder conservation, rearing improved breeds, and vaccination of livestock. Women are more likely to adopt strategies aimed at diversifying production and post-harvest value-added activities such as food storage facilities and tree planting compared to men who engage mainly in farming and livestock keeping.

On-farm adaptation practices

Farmers adapt to climate change and variability in a number of ways. On-farm interventions in Tharaka Nithi County are mostly geared towards methods of harvesting or conserving water to boost crop production and improve pastures. According to a survey by ASDSP, the households employed a number of strategies to adapt to climate change. Overall, 66 percent of the households used soil and water conservation, 50 percent planted trees, 31 percent diversified into other agricultural activities, and 30 percent changed livestock enterprises. Overall, 23 percent had been trained on soil and water conservation, 20 percent on tree planting, 25 percent on changing crop type, and 22 percent on staggered cropping (GoK, 2014).

The on-going and potential adaptation options for crop farmers include growing improved drought-resistant crop varieties, rain water harvesting, conservation agriculture, crop rotation, and intercropping, afforestation, and irrigation. Livestock farmers adapt by practising feed and fodder conservation methods during the high supply season, using farm residue and other by-products, supplementing feeds, increasing the area under pasture and fodder, and using efficient dairy breeds. These strategies are adopted by farmers, farmer organisations, and extension services from the Government, NGO's, and development partners. The government has also come in to subsidise AI services. To address the challenge of accessing extension services and AI service providers, the farmers use mobile phones to call and also consult fellow farmers. If AI services are not accessible, the farmers resort to bull insemination. They also deploy indigenous technologies and knowledge to treat the animals. Farmers are using local bulls in some areas. The infrastructure is affected when it rains as the roads are rendered impassable. In such situations, farmers use motorbikes or they walk to get to market areas to deliver milk and also buy feeds. During dry periods, the farmers feed the animals on crop residues such as maize stalks, banana trunks, and reeds from rivers. The farmers further improve the feeding strategies through home-made rations using available ingredients. Effective use of these strategies will however require capacity building through the extension services.

The biggest challenge to value addition in the livestock and crop sector is lack of capacity in terms of know-how, equipment, and resources. The challenge of poor access to markets has not been addressed satisfactorily

by the on-going adaptation strategies such as selling individually, value addition (given that it is minimal) and premature harvesting. These strategies can be complemented with options such as collective selling, training farmers, providing the required resources for value addition, and engaging farmers in contract farming. Encouraging farmers to organise themselves into groups can also help in reducing the cost incurred in transportation. The farmers ought to invest in fodder production. This includes producing disease-tolerant Napier grass and fodder trees. Additionally, through support from the extension department, the farmers should be trained on making silage or hay.

To manage and lessen the effects of climate change, the county must step up efforts towards adoption of renewable and alternative sources of energy. There is need for introduction of and capacity building on improved crop varieties, better-adapted livestock breeds, food processing, and preservation techniques, as well as diversification of food production and establishment of food banks to increase resilience to climate change.

Off-farm adaptation practices

Off-farm services such as early warning systems, extension and training, credit, storage facilities, and market information are offered to farmers in Tharaka Nithi County to increase their climate adaptive capacity. Such services were mainly offered by MoALF, Methodist Church, Meru Greens, Africa Harvest, National Drought Management Authority, and Technoserve. Others are Meru Herbs Ltd, Muthiru Dairy-milk Processing, Sun-n-Dried-banana Processing, Bairunyi Beekeepers, Kaka Maize Millers, Weru Tea Factory, Kenfood, and Gelmark Enterprise. Extension services involve field visits, focus group discussions, and workshops on aspects related to the entire value chain. These include: crop planting and growing times, input utilisation and value addition, and amount of product to sell on the market. Extension training includes fodder conservation, post-harvest handling, proper storage, beekeeping, and marketing. In the livestock sector, farmers have been trained on the importance of destocking and feed storage, which helps increase production. A challenge to the early warning systems is that many farmers neglect the information; moreover, high illiteracy levels limit the reach and effectiveness of the messages.

Farmers, through various extension service providers, are also being encouraged to plant 'orphan crops' or drought-resistant crop varieties like millet, pigeon peas, cowpeas, and green grams, which adapt well to climate variability. They are also being encouraged to keep livestock breeds that are climate smart. KALRO, which has a substation in Marimanti, has involved farmers in conducting trials of crops in their plots. Farmers are involved in the management of the crops in the trial plots and upon harvest, most of the yield is left for them. As an alternative option, farmers have been seeking off-farm employment opportunities such as sand harvesting and charcoal burning, while others have move to urban centers in search of jobs.

Adapting agriculture to changes and variabilities in climate: strategies across major value chain commodities

Poultry

	Provision of seeds and other inputs	On-farm production	Harvesting storage and processing	Product marketing
Increased temperatures	Poor health of chicks and increased mortality due to heat stress. Reduced availability and increased cost of feed. Spoilage of vaccines	Increased pests and diseases. Increased water requirements. Heat stress affects growth of chickens. Temperatures exacerbated by use of metal roofed enclosures	High costs for cold storage. Increase in spoilage of meat and eggs. Discolouring of meat before and during grading	Reduced income for farmers. Reduced shelf life of meat and eggs
Magnitude of impact	Major	Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Home treatment and supplementation for chicks (multivitamins, glucose and liquid paraffin). Use of Traditional herbs (Aloe spp). Use of locally available feed (millet). Use of cooling material (e.g. grass) in brooding enclosure	Use of locally available materials to cool enclosures (e.g. banana leaves). Use of traditional medicines (e.g. Aloe spp and pepper) to treat chickens	Use of ice for cooling and cooler boxes. Using nylon plastic bags for packaging and then placing the packaged chickens in cold water. Harvesting and slaughtering in early morning or night time	Local household consumption. Transport using small cages with few birds. Sales at local poultry sales yards. Night time transporting
Other potential options to increase farmers' adaptive capacity	Development of local feed formulation enterprises. Use of modern incubators. Improved breed development and selection. Promote electric ventilation (e.g. fans)	Train farmers on construction of improved (ventilated and temperature regulating) enclosures. Use of thermostats and temperature regulating brooders. Train farmers on appropriate vaccine regimes	Use of ice for cooling and cooler boxes. Using nylon plastic bags for packaging and then placing the packaged chickens in cold water. Harvesting and slaughtering in early morning or night time. Investment in ice making machinery and cold storage facilities. Investment in modern slaughter houses and in refrigerated vehicles. Capacity building on meat handling. Invest in modern grading and labelling equipment	Capacity building on marketing. Procurement of special poultry transport vehicles. Establish contract farming. Increase number of shaded poultry sales yards
Droughts / Moisture stress	High mortality and slow growth rate of chicks. Feed shortages and increase in prices of inputs. High demand for vaccines resulting in shortages	Slow growth rate of chickens. Increased incidence of disease. Increased need and costs for veterinary care. Increased costs related to provision of feed and water	Reduced quantity and quality of meat and eggs harvested. Reduced shelf life. High spoilage rates	Lower prices for chickens and eggs due to lower quality
Magnitude of impact	Moderate	Moderate	Minor	Moderate
Farmers' current strategies to cope with the risks	Use of local ingredients to supplement feed. Use of traditional feeds	Use of growth promoters. Use of traditional medicines (e.g. Aloe spp and pepper) to treat chickens	Defeathering without water or with reused water. Destocking (slaughtering and sales of entire stock)	Local household consumption. Sales at local markets
Other potential options to increase farmers' adaptive capacity	Improved breed development and selection. Construction of feed factory	Capacity building on improved health management. Train farmers on appropriate vaccine regimes	Investment in modern slaughter houses. Capacity building on meat handling and value addition. Invest in modern plucking, weighing, grading and labelling equipment	Use of specialised poultry transport vehicles. Contract chicken farming. Linkage of chicken farmers to suppliers

Green gram

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Increased temperatures	Reduced demand for seed, fertiliser and agrochemicals. Increased spoilage of seeds	Heat stress and increased water requirements; slower growth. Rapid weed growth. Poor seed germination. Increased incidence of pests and diseases. Crop wilting	Rapid drying of pods. Shattering of some pods. Reduced quality of produce. Increased cold storage requirements	Heat makes movement of people and goods to market difficult. Increased transportation costs
Magnitude of impact	Major	Major	Moderate	Moderate
Farmers' current strategies to cope with the risks	Seed recycling. Borrowing seed from friends. Purchase from informal markets. Use of organic manure	Use of integrated pest, weed and disease management. Seed broadcasting during ploughing. Planting and weeding during early morning or evening. Intercropping	Shade drying (under trees). Brief storage in sacks before sales at markets	Sales to brokers. Sales by the tin
Other potential options to increase farmers' adaptive capacity	Formation of farmer cooperatives to provide certified seeds on credit. Introduction of cover crops. Introduce community based seed bulking	Training on conservation agriculture practices – mulching for temperature and water regulation. Mechanized planting. Training on weed management and proper seed planting methods	Establishment of aggregation centres. Shading of pods with tarpaulin. Construction of shaded storage facilities by cooperatives. Use of mechanised threshers to reduce post-harvest losses. Use of hermetic bags, silos, improved warehouses. Promote use of moisture metres to enhance storage	Promote contract farming. Creation of government warehouse receipts system. Formation of producer/ marketing groups. Investment in modern market pricing information systems. Promotion of digital weighing machines and bulk sales of produce
Droughts / Moisture stress	Lack of availability of seeds. Reduced purchase of agrochemicals	Extra labor (and costs) in land preparation (breaking hardpans) and weeding. Low germination rate. Wilting	Low yields. Poor quality produce. Easier storage and processing; reduced incidence of fungal diseases	Lower supply to market. Reduced transportation costs. High demand
Magnitude of impact	Severe	Major	Minor	Minor
Farmers' current strategies to cope with the risks	Seed recycling. Borrowing seed from friends. Purchase from informal markets. Exchange of seeds with friends and neighbours. Use of uncertified seeds	Delayed land preparation (until onset of rains). Reduce area of land planted. Early planting/ dry planting. Use of conservation agriculture principles (minimum tillage, intercropping). Mulching with millet plant residue	Use of storage chemicals to reduce post-harvest losses. Mortar and pestle for grinding. Home consumption	Farm gate sales in small quantities. Travel to markets with samples. Sale by tin
Other potential options to increase farmers' adaptive capacity	Formation of farmer cooperatives to provide certified seeds on credit. Introduction of cover crops. Introduce community based seed bulking	Water harvesting. Introduction of sub-soilers and rippers to improve seed planting environment. Scaling up and capacity building on conservation agriculture	Use of hermetic storage bags. Establishment of aggregation centres. Use of digital weighing machines for bulk sales. Use of moisture meters to reduce storage losses	Promote contract farming. Formation of producer/ marketing groups

Goat (meat)

	Provision of seeds and other inputs 	On-Farm production 	Harvesting storage and processing 	Product marketing 
Increasing temperatures	Reduced availability and quality of feed and pasture. Reduced breeding	Poor health and body condition of animals. Increased water needs. Increased vulnerability to pests and diseases. Increased costs related to heat and disease management	Reduced market value. Low weight of goats	Low prices of livestock for farmers. Reduced household income. Low volumes traded
Magnitude of impact	Moderate	Moderate	Moderate	Major
Farmers' current strategies to cope with the risks	Feed supplementation and fodder production and storage. Use of crop residue for feed	Reduce stock (removal of weak animals). Construction of shade structures. Diversifying from goat farming. Construction of simple goat enclosures	Slaughter at local markets	Local sales and consumption. Sales to middle men. Transport to market using motorbikes
Other potential options to increase farmers' adaptive capacity	Training on supplementary feeding. Capacity building on pasture management. Dissemination of feed formulation technologies and information. Promote heat tolerant breeds	Train farmers on construction of goat enclosures. Capacity building on disease surveillance and management	Establish shaded holding grounds and cold storage facilities. Construct abattoirs. Capacity building on value addition of goat meat	Capacity building for cooperatives on pricing and marketing. Establish contract goat farming. Establish shaded marketing centres. Promote sales by weight
Droughts / Moisture stress	Scarcity of good quality pasture and feed. Scarcity of water	Poor health and body condition of herd. Increased mobility in search of water and pasture. Increased labor for farmers. Increased pests and diseases. Increased husbandry costs	Reduced market value of stocks. Reduced volumes for processing. Household consumption. Low quality hide	Low prices of livestock for farmers. Reduced household income. Mortality during transport to market. Reduced bulk buying
Magnitude of impact	Major	Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Fodder production. Feed supplementation. Use of crop residue for feed	Moving animals to find fodder and water. Use of local medicines to treat opportunistic diseases	Early and late evening and night transportation; early slaughtering of goats when temperature are cool; trekking of animals at morning, nights and late evening; increased slaughtering	Watering interval reduced to improve body condition; immediate selling of skin; traditional market without facilities
Other potential options to increase farmers' adaptive capacity	Training on production and conservation of homemade feeds and feed supplementation Introduction of drought tolerant fodder plants. Construction of hay banks and fodder storage structures. Commercialisation of fodder production.	Water harvesting for livestock. Capacity building on livestock management and stock control. Training on rangeland management	Training of farmers on value addition. Construction of modern slaughterhouses. Establishment of cold storage facilities.	Establish goat marketing centres in different locations. Capacity building of cooperatives on marketing and sales.

Cattle (milk)

	Provision of seeds and other inputs 	On-farm production 	Harvesting storage and processing 	Product marketing 
Increasing temperature	Feed and hay scarcity. Reduced quantity and quality of pasture. Increased veterinary health care requirements	Low milk production. Low fertility and reproduction rates. Low weight gain. Increased management costs	Reduced milk quantity and quality. Increased costs for milk storage, handling and transportation. Increased spoilage of milk	Unreliable supply to the market. Lower returns for farmers due to low quality and quantity of milk produced
Magnitude of impact	Moderate	Moderate	Major	Major
Farmers' current strategies to cope with the risks	Storing and conserving pastures and fodder. Use of crop residues as feed. Use of kitchen waste as feed	Construction of low cost shaded enclosures	Use of shared milk storage facilities. Group sharing of costs for use of cold storage facilities	Formation of milk marketing cooperatives. Sales in the local market with minimal value addition
Other potential options to increase farmers' adaptive capacity	Dissemination of heat tolerant breeds. Training on breed selection. Training on fodder production. Water harvesting and irrigation for fodder production. Purchase of feed mixers for on farm feed production and rationing	Microcredit for shaded enclosure construction. Support design of dairy enclosures for farmers. Adhering to animal health management guidelines. Capacity building on detection of animal heat stress. Water harvesting for livestock	Expand cold storage facilities to all collection centres. Value addition (long life milk and milk powder) equipment and training. Dissemination of sustainable energy technologies for powering cold storage facilities	Collective marketing through cooperatives (dairy farmer groups). Scale up contract milk farming. Enhance access to microfinance for milk cooperatives
Droughts	Feed and hay scarcity. Reduced quantity and quality of pasture. Increased veterinary health care requirements	Low milk production. Increased susceptibility to pests and diseases resulting in increased animal health management costs	Lower availability and quality of milk products. Increased costs for packaging and storage. Dusty conditions lead to milk contamination	Low returns for farmers due to low quality and quantity. Decline in supply to the market
Magnitude of impact	Major	Moderate	Major	Major
Farmers' current strategies to cope with the risks	Storing and conserving feed and fodder. Use of crop residues as feed. Purchase of hay and fodder	Vaccination of animals by government. Introduction of alternative fodders (oats, vetch and desmodium)	Consumption of milk at household level (priority to those in household who need it most). Small scale investment in milk refrigeration equipment	Pooled transportation of milk. Sales at local markets
Other potential options to increase farmers' adaptive capacity	Promotion of drought resistant forage and fodder. Invest in drought resistant breeds. Training on fodder production. Commercialisation of fodder production. Expansion of artificial insemination services to improve breeding stocks	Promote water harvesting for livestock. Improved livestock health management. Investing in weather resistant dairy enclosures	Construction of large milk cold storage facilities. Training on milk value addition e.g. milk powder production. Establishment of modern milk collection centres. Training on milk handling and storage	Organise group marketing though cooperatives. Scale up contract milk farming. Improve access to microfinance for milk production. Improve road networks for easy access to milk markets

Policies and Programmes

The Tharaka-Nithi County Climate Change Taskforce is a five-member task force formed in October 2013 and reconstituted in 2014. It comprises representatives from the Agriculture Sector Development Support Programme (ASDSP), National Drought Management Authority (NDMA), NEMA, CARITAS, and Chuka University. The thematic working group is responsible for overseeing Participatory Scenario Planning (PSP) workshops through which the KMD, community members, county government and local civil society organisations share climate forecasts, develop climate impact scenarios based on these forecasts and use the scenarios to make action plans and recommendations, or advisories. The PSP workshop aims to interpret and provide user-friendly climate information that has not traditionally been available for local communities and county government to use when planning for the coming season. The initiative is implemented through the ASDSP project in collaboration with the Kenya Meteorological Department (KMD). Among the target stakeholders are the county government, the national government, farmers, pastoralists, and agro-based business persons. Farmers and traditional forecasters are all involved in the process as they have indigenous knowledge on weather information; and can give their perspectives on climate trends, allowing traditional information to be fused with scientific information. Information is thereafter disseminated to farmers through various channels such as posters written in English, Kiswahili, and the local language; or through radio, social media, WhatsApp, and email.

The climate change task force has developed the Natural Resource Management Draft Policy which aims at providing a holistic framework to guide the management of the environment and natural resources in the County. It further ensures that the linkage between the environment and poverty reduction is integrated in all the County government processes and institutions. This is to facilitate and realize sustainable development at all levels in the county government within the context of the green economy while enhancing social inclusion, improving human welfare, and creating opportunities for employment and maintaining the healthy functioning of the ecosystem. Other bills include the Sustainable Land Management Bill and the Sand Harvesting Bill (GoK, 2014a).

The crops sub-sector in the County is guided by several national policies and legislations whose overall objective is to promote food security and incomes; advance agro-based industries, employment creation, and agricultural exports; and enhance sustainable use of land resources as a basis for agricultural enterprises. These national policies and legislation are: The National Food and Nutrition Security Policy, the National Agriculture Service Extension Policy, the National Agri-Business Strategy, the National Horticulture Policy, the National Root and Tuber Crops Policy, and the Kenya Seed Policy. Most policies within the sub-sector have embraced issues addressing interests of men, youth, women, and persons with disabilities among other vulnerable groups. To further this social inclusion, the Agri-business Strategy has identified and provided support to SMEs run by women, youth, and persons with disabilities.

The livestock sub-sector is guided by the National Livestock Policy, whose overall goal is to enhance the sub-sector's contribution to GDP and food security, as well as create employment opportunities and improve livelihoods and revenue generation through effective private, public, and community partnerships. Several other Acts including the Animal Diseases Act, Cap 364; the Veterinary Surgeons and Veterinary Para Act, No 29 (2011); the Meat Control Act, Cap 356; the Hides, Skins, and Leather Trade Act, Cap 359, the Dairy Industry Act, Cap 336, and the Draft Veterinary policy provide further policy guidance to the operation of the sector at both national and county level (GoK, 2014a).

The land reforms policies, strategies, and legislation that are in existence include: Environment and Land court Act, 2011, the National Land Commission Act, 2012, the Land Act 2012, Land Registration Act 2012, and Sessional paper No 3 of 2009 on National Land Policy. Tharaka-Nithi County included the following issues in these policies: inhibitive cultural practices, demographic shifts and urbanisation, disparities in land ownership, unsustainable land use, climate change, conflict in land laws, and manual land information system.

The Agricultural Sector Development Support Programme (ASDSP) was formulated by the government in 2011 in collaboration with development partners and other stakeholders to support implementation of the strategies identified in the Agriculture Sector Development Strategy, ASDS (2010 – 2020) and the Comprehensive African Agricultural Development Programme (CAADP) Kenya Compact. The programme focuses on improved agricultural sector coordination and harmonization; strengthening of the environmental resilience and social inclusion of Value Chains (VC); and promotion of viable and equitable commercialisation of the agricultural sector through Value Chain Development (VCD). The main purpose of ASDSP is to increase equitable income, employment, and food security of male and female target groups as a result of improved production and productivity in the rural smallholder on-farm and off-farm sectors (GoK, 2014). However, in spite of the importance of the sector and the programmes, agriculture has for many years been predominantly small scale, rain-fed, and poorly mechanised. In addition, institutional support and infrastructure have

been inadequate. The development of agribusiness at local level is critical to the commercialisation of agriculture and realisation of Kenya's Vision 2030.

The county government through the Traditional High Value Crops (THVCs) programme has been providing tons of assorted crop seeds and varieties across the county. The THVCs Programme, which started in 2007, has continued to provide the drought-prone population in Tharaka with a number of drought-tolerant crop varieties. Most crops being provided include green grams, cowpea, beans, pigeon pea, sorghum, bulrush millet, and to some limited extent finger millet and cassava. The programme works closely with KALRO in seed bulking where they have formed seed development units. The groups produce seed under the KALRO license while KEPHIS conducts seed certification. A large number of seed-bulking farmers, who comprise about 2,500 groups, have benefited from the venture. In 2016, the national government and European Union launched a programme to help smallholder farmers to invest in commercial agriculture and earn better returns. The public/private partnership has enabled small-scale farmers including youth from the county to get certified agricultural inputs and banking services in order to increase crop productivity. Through the Kenya Cereals Enhancement Programme (KCEP), the International Fund for Agricultural Development (IFAD) and Equity Bank are offering technical and financial support to the farmers while the Cereal Growers Association (CGA) is responsible for farmer group development, advisory services, and capacity building of county agricultural officers. KALRO is acting as an implementing partner charged with dissemination of research-based technical packages, soil sampling, and mapping.

Despite these programmes and policies, there is no local level legislation on climate change for Tharaka Nithi County. These factors reduce the degree of coordination and collaboration. Coordination among organisations mentioned above exists at some stages of intervention design and implementation, as well as within government departments, however this can be improved. There has also been limited profiling of the characteristics and underlying factors affecting vulnerability in the community, thus hindering the design of appropriate intervention programmes and the necessary resource mobilisation. Insufficient funding also contributes to lack of both technical and operational capacity on resilience related issues within government departments and other organisations operating in the county.

Governance, institutional resources, and capacity

Tharaka Nithi County has several institutions that operate in the agricultural sector. These have been broadly categorised into those dealing in extension services, marketing, finance, value addition, research, ICT, and training. There are various governmental, non-governmental (NGOs), community-based, faith-based, and private organisations in the county that directly or indirectly deal with climate risks. County-level government and research institutions include local offices of the Ministry of Agriculture, Livestock and Fisheries (MOALF), the Ministry of Water and Irrigation (MoWI), the National Irrigation Board (NIB), the Ministry of Lands, the Kenya Meteorological Department (KMD), the Kenya Forestry Service (KFS), the National Environmental Management Authority (NEMA), the Kenya Wildlife Service (KWS), Kenya Agricultural and Livestock Research Organisation (KALRO), the Kenya Dairy Board (KDB), and the National Drought Management Authority (NDMA).

County governments are the main providers of agriculture and livestock extension services while the national government formulates policy, develops extension services delivery standards, and builds capacities of service providers. Other extension service providers include agro-veterinary pharmaceutical companies, animal feed manufacturers, milk processors, Non-Government Organisations, and Community-Based Organizations. Specific interventions include construction of water facilities such as boreholes and dams by the water department and NIB, vaccinations by the veterinary department, promotion of pastures by the agriculture department, improved crop varieties and breeds by KALRO. Tree planting and controlled deforestation are being promoted by KFS, dairy regulation by KDB, regulation of livestock movement by KWS, regulation and coordination of various environmental projects by NEMA, and policy support by ASDSP. The NDMA is the only organisation that directly deals with climate change risks, providing early warning information to farmers in collaboration with KMD.

Several NGOs are working in the county. They include The Swedish International Development Cooperation Agency (SIDA) and UKAid that supported a five-year project starting 2012 with Non-State Actors (NSAs) in the Natural Resources Sector that is hosted at the

NGO Act (Act Change Transform), also referred to as the Changieni Rasili-Mali (CRM) Facility. The NSAs in Tharaka Nithi included DETRA-Africa, Center for Research in Environment Kenya (CREEK-Kenya), Rural Initiative Development Kenya (RIDEP), Institute of Culture and Ecology (ICE), Grassroots Development Initiatives Foundation-Kenya (GRADIF-K), and CARITAS. The overall objective of the project was "Improved participation by citizens, including the poor, in the governance and sustainable utilisation of natural resources in Kenya". GRADIF-K has also undertaken a 3-year project funded by the Alliance for a Green Revolution in Africa (AGRA) in 2015 with the goal of increasing small-holder farmers' incomes and livelihoods through strengthening of Farmer Organisations (FOs). The Organisation is training farmer groups on crop and livestock farming, record-keeping, and value addition. The organisations also have a development component, providing extension, inputs such as fertilisers, high-yielding seeds, and improved livestock breeds to farmers. Through this programme, many farmers have learnt how to harvest and harness water during the dry season. The project's aim was to increase food supply and eradicate poverty by creating jobs for Kenyans and in the long run stabilise prices and lead to food security. The NSA's have helped build the capacities of local farmers in the county to increase their produce in the changing environmental conditions as well as effectively address key value chain issues like quality production, value addition, marketing, and competitive pricing for their farm produce.

Various NGOs have distributed local goats as part of their rehabilitation or development programmes in Tharaka Nithi County a part of livelihood support programmes or following droughts, however such programmes are seldom accompanied with much training on how to improve performance of the goats distributed. Caritas Meru's Arid and Semi-Arid Lands Resilience Programme has supported the establishment of an irrigation scheme for 500 households in the community. Farmers in the programme also learn techniques to adapt to their changing climate, including conservation agriculture, crop diversification, use of drought-tolerant seeds and water-sensitive planting techniques, and planting a variety of crops.

Since 2004, the Government of Kenya and IFAD have financed the Mount Kenya East Pilot Project (MKEPP), which has linked sustainable use of natural resources, especially water and forests, with enhancement of rural livelihoods. Thereafter, the Government of Kenya received financial assistance from the International Fund for Agricultural Development (IFAD) and the Spanish Trust Fund towards financing an eight-year (2012-2020) Upper Tana Natural Resources Management Project called Upper Tana Catchment Natural Resources Management Project (UTaNRMP). The goal of the project is to contribute to rural poverty reduction in the Upper Tana River Catchment through increased sustainable food production and incomes and sustainable management of natural resources for provision of environmental services. The Project Lead Agency is the Ministry of Water and Irrigation Services. The project covers six counties, one of them being Tharaka Nithi. Some of the activities of the project include: development/rehabilitation of rainwater harvesting and storage including water pans and dams; roof water harvesting demonstration for public institutions; rehabilitation/ development of boreholes, shallow wells and springs, rehabilitation of road embankments; quarries, and denuded hilltops, and eroded riverbanks, wetlands and springs at Gikingo, Marimanti, and Nkondi locations; it has benefited 2100 people.

Sweet N Dried is a start –up company formed by a young couple in the county that deals with value addition. It started production in 2011 at Chuka Igamba Ng'ombe region, where it focused on producing banana flour and dried mangoes and now makes several products including banana flakes and flours from pumpkin and sweet potato. It has engaged over 244 farmers in the area to supply them with raw materials. Such value addition enterprises could be expanded to the value chain identified in this profile.

Through USAID/KAVES, farmers have been trained through demonstrations, farmers' field schools, field days, trade fairs, exchange visits, and farmer-to-farmer trainings, with content of training including fodder establishment, harvesting and conservation, cow nutrition, housing, hygiene and sanitation at the farm, calf rearing, breeding, and group governance and management. Farmer trainings have been conducted in collaboration with the county government and other private and public industry players. Farmers have also been linked to suppliers of productivity-enhancing technologies, inputs, and services.

Effective preparedness for and management of climate change impacts will largely depend on the establishment of an all-inclusive coordination mechanism that will bring together various key actors working on climate change adaptation and resilience building in the county. Building the financial, technical and operational capacity of research and extension institutions in the county are also key in enhancing resilience and productivity in crop and livestock production. The main constraints in research and extension service delivery in the county

include low investment in agricultural research by public and private sectors, inadequate attention to post-production research (particularly value-addition and marketing), and inadequate mechanisms for dissemination of the research findings. Farmer field schools and participatory farmer research may provide opportunities for enhanced farmer knowledge and awareness on resilience and adaptation related practices, technologies and innovations. While many stakeholders have focused on the on-farm production aspects, greater effort needs to be placed on the input supply, value addition and marketing of agricultural value chain commodities focused on in this profile, particularly given that weather variability is already affecting the quantity and quality of produce available for value addition.

Synthesis and Outlook

As moisture stress and increases in temperatures are foreseen to occur with greater frequency in Tharaka Nithi County in the future, enhanced capacity of farmers to cope with these new conditions is needed. This involves critical short- and long-term adaptation measures that target production systems and value chains key to the population's food security and livelihoods, including livestock and crop systems. Significant initiatives to increase resilience in the agricultural sector have been evident in the County. Support to on-farm production has been the primary focus; however, without ensuring enabling conditions for provision of and access to inputs such as seeds, fertilisers, pesticides, as well as product storage and market access, farmers' livelihoods and incomes will remain highly vulnerable to both climate hazards as well as market shocks. Distribution of inputs, mainly seeds and fertilisers, should be timely and synchronised with rain cycles, requiring support and awareness raising for agrodealers as well as collaboration with the meteorological department on dissemination of seasonal weather forecasts. This will address claims by farmers that inputs are not available by the on-set of rains.

Also, of particular importance are investments in road infrastructure that can enable farmers to access markets, as well as important services such as extension and veterinary support. Moreover, value addition can open up new niche markets for farmers, particularly for export, thereby increasing incomes and resilience. For example, drier zones of the county produce very high quality honey that can be processed, branded, and marketed locally and internationally to support the region's economy (GoK, 2013).

In addition, off-farm services and programmes have been provided to act as enablers for uptake of adaptation options. Such services and programmes include provision of early warning systems, extension services, and technical support. Apart from these measures, a long-term vision for the agricultural sector requires addressing underlying factors that increase farmers' vulnerability and diminish their capacity to carry out climate change adaptation activities more effectively. Investments in basic public services such as availability of and access to potable water, electricity, and education could help curb persistent high poverty and illiteracy levels among farmers. These would enable them to invest in activities that secure their livelihoods and allow access and appropriate use of vital agricultural inputs (fertilisers, vaccines, irrigation equipment) that will maintain and eventually increase productivity and incomes as well as build resilience to weather variability and climate shocks.

Lack of skilled manpower continues to affect new technology development and uptake, especially in agro-industry investment ventures. Limited technological uptake is also a major impediment to innovation within the agricultural sector. The main institutional strength was identified as human capital, while on the other hand institutions performance was hampered by inadequate financial resources and limited coordination of resilience and adaptation related institutions.

An enabling institutional and policy environment is critical for addressing climate vulnerabilities of farmers. The formulation and implementation of county-level climate change action plans that are grounded in assessment of local needs and resources will represent an important step towards the county level operationalization of the country's climate change strategies. Identification of an appropriate local institution to implement the National Climate Change Action Plan, which should cascade to the vulnerable smallholder farmers, is recommended. Also of importance is the improvement of the current early warning and climate change monitoring systems, which should incorporate local knowledge, assessments of the vulnerabilities, risks and impacts, on smallholder farmers that form the majority of the rural population and early warning in droughts, floods and temperature rise management; and provision of appropriate financial, human resources and equipment to deal with the issues related to smallholder agriculture and impacts of climate change on their livelihoods. There is also need to strengthen the capacity of KMD so as to strengthen weather monitoring, early warning, and drought warning systems and extend it to crop yield

forecasts by providing the necessary skills, funds and capacity building at the community level.

The major hindrance to successful climate risk interventions in the county is lack of timely and sufficient funding. Insufficient funds contribute to inadequate operational capacity, usually reflected in limited resources and staff in various government departments and other organisations.

Various productivity and resilience related projects and programmes have been implemented in the county, largely focusing on on-farm production and to a lesser extent input support and veterinary services. While it is important to continue implementing such initiatives, integrated agricultural development and climate risk reduction requires measures that target the entire range of value chain activities from input supply to marketing as well as off-farm services such as climate information and extension. The county leadership also needs to develop a commodity-by-commodity development plan (including crops and livestock mentioned in this profile as well as others) with specific yield, value addition and marketing targets against which progress can be measured and resilience investments targeted.

Lastly, programming has not adequately addressed gender and generational biases leading to the exclusion of vulnerable groups such as women and youth in responding to the challenges of weather variability and climate change. Capacity (human and financial) and knowledge among non-governmental organisations (NGOs), government officers and community leaders among others, with regard to climate change-related approaches is still limited, which has led to a lack of mainstreaming of climate change adaptation in their work. Weak partnerships, linkages, and coordination among community-based organisations (CBO), NGOs, sectoral ministries and development partners have contributed to a lack of synergy and complementarity among actors, resulting in limited impacts in terms of improving community resilience to sustainability challenges and effects of climate variability and change. The county government in liaison with all the relevant stakeholders needs to strengthen early warning systems to enhance drought preparedness and mitigation.

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