Assessment of gender and innovations in climate-smart agriculture for food and nutrition security in Kenya: a case of Kalii watershed

Dave Nyongesa*

Kenya Agricultural and Livestock Research Organization (KALRO),
Food Crops Research Institute,
Kabete Research Centre,
Socio-Economics and Policy Development Unit,
P.O. Box 14733-00800 (Westlands), Nairobi, Kenya
Email: Dave.Nyongesa@kalro.org
*Correspondences author

Anthony O. Esilaba

KALRO Headquarters,
Natural Resource Systems Sub Unit,
P.O. Box 57811-00200 (City Square),
Nairobi, Kenya
Email: anthony.esilaba@kalro-org

Rosemary Emongor

KALRO, Food Crops Research Institute,
Kabete Research Centre,
Socio-Economics and Policy Development Unit,
P.O. Box 14733-00800 (Westlands), Nairobi, Kenya
Email: remongor@gmail.com

Edward Bikketi

International Crops Research Institute for the Semi-Arid Tropics
(ICRISAT-ESA), Gender Research Division,
P.O. Box 39063-00623 (United Nations Avenue, Gigiri),
Nairobi, Kenya
Email: e.bikketi@cgiar.org
Email: edwardbikketi@gmail.com

Kennedy Were

KALRO, Food Crops Research Institute,
Kabete Research Centre,
P.O. Box 14733-00800 (Westlands), Nairobi, Kenya
Email: kenwerez@gmail.com

Abstract: Climate-change and variability (CC&V) exerts multiple stresses on agriculture production. It negatively impacts gender-cadres especially in Kenya's arid and semi-arid lands that occupy 89% (area), 36% (population), 70% (livestock), and 90% (wildlife). Smallholders with limited resources endowments have adopted climate-smart agriculture technologies, which are viewed as a panacea to CC&V in addressing interlinked food-security challenges. This paper reports baseline survey results on 149 randomly selected households in Kalii watershed. Primary and secondary data were collected in March 2015. Data-analyses encompassed regressions, descriptive statistics and gender-analysis. Local perceptions/results revealed precipitations downward-trend and an upward-trend of temperatures, and other elements, and outcomes of CC&V. Gender and innovations are statistically significant at ($p<0.05$). Decision-making on assets' and proceeds' control and use, was men's domain. Invariably, gender and climate-smart agriculture innovations are critical in food and nutrition security strategy under CC&V.

Keywords: gender; agriculture; watershed; smallholders; food-security; climate-change and variability; decision-making; innovations; livelihoods; assets; improved-leguminous crops.

Reference to this paper should be made as follows: Nyongesa, D., Esilaba, A.O., Emongor, R., Bikketi, E. and Were, K. (2017) 'Assessment of gender and innovations in climate-smart agriculture for food and nutrition security in Kenya: a case of Kalii watershed', *Int. J. Agricultural Resources, Governance and Ecology*, Vol. 13, No. 2, pp.109–137.

Biographical notes: Dave Nyongesa holds a PhD in Economics and works at KALRO Food Research Institute, KALRO Kabete Research Centre in the Socioeconomics and Policy Development Unit. He is a Principal Research Officer who has research experience of >20 years. He underwent gender training for three years (2004–2006). He is KALRO's Coordinator for Gender, Social and Participatory Methods. He serves as ASARECA's Gender Focal Person for Kenya/KALRO. He has implemented many projects in gender mainstreaming, participatory methods, commodity value-chains and HIV/AIDS. Currently he is implementing Kenya Cereals Enhancement & Climate Resilient Agricultural Livelihoods Programme in eight counties in Kenya.

Anthony O. Esilaba is a Soil Scientist, Senior Principal Research Scientist and Assistant Director and Head of the Natural Resources Systems Sub-Unit at the Kenya Agricultural & Livestock Research Organization (KALRO) Secretariat in Nairobi, Kenya. His responsibilities include assisting the Director of the Environment and Natural Resource Systems Research Programme in the national coordination of the planning, programming, coordination and execution of research programmes in five sub-programmes that include soil and water management, integrated soil fertility management, land use planning, environment and climate-change and irrigation, drainage and management of problem soils. He has over 30 years' research experience and various publications.

Rosemary Emongor holds a PhD in Agricultural Economics from the University of Pretoria and has over 25 years of professional experience in Socio-economic research. She is a Senior Principal Research Officer in the KALRO which was formerly KARI and was the Coordinator for Markets Research and Analysis Programme. She has worked extensively in collaborative projects with multi-institutional and multi-lateral donors' projects such as those funded under DFID, World Bank, DGIS and ASARECA. She is currently involved in a number of projects such as "Sustainable Agricultural water Productivity for Improved Food-security and Nutrition in the ECA funded by ASARECA."

Edward Bikketi holds a PhD in Social Anthropology and Sustainable Development (University of Bern), an MA in Rural Sociology and Community Development (University of Nairobi) and a BA in Sociology and Economics (Catholic University of Eastern Africa). He gained a doctoral research experience with the National Swiss Centers for competence in research focusing on social capital among farmer field schools/groups in Kenya. He has over 10 years' socio-economic research experience at the Kenya Agricultural & Livestock Research Organization at KALRO-Kabete. Currently, he is a Postdoc Research Associate at the International Crops Research Institute for Semi-Arid Tropics, Gender Research Division.

Kennedy Were holds a PhD in Geomatics and works for the Kenya Agricultural & Livestock Research Organization as a research officer. His interest lies in utilisation of satellite remote sensing and geospatial techniques for environmental monitoring and management, with a strong focus on land use change and the impacts on ecosystems services. He has experience in assessing land degradation in major watersheds in Kenya, as well as in digital soil mapping. His most recent project tried to understand how land use changed in the Lake Nakuru drainage basin and Eastern Mau Forest, and how the changes affected soil carbon storage.

1 Introduction

Gender is about norms, values, customs and practices by which biological differences are translated into social differences between men and women. It shapes the different ways in which women and men participate in and benefit from agricultural interventions (FANRPAN, 2012). Existing context specific gender inequalities prevent societies from realising their full potential in all the activities of economic, social and political development. Men and women play critical and complementary roles in agricultural production, processing, marketing, utilisation and management of pertinent natural resources. Increasing food production relies heavily on the labour of women. Interventions such as Climate-Smart Agriculture (CSA) must be gender responsive and transformative in order to achieve sustainable and resilient rural livelihoods without disadvantaging any gender. Nevertheless, what is climate? Climate (C) refers to average patterns of precipitation, temperature, wind speed and direction, relative humidity, radiation, sunshine hours, and seasons over a long period of time. Regular and predictably patterned seasons, timely rainfall in the right quantities and conducive temperatures facilitate growth of crops for humans and pastures for livestock feed. It further determines availability of water for both human and livestock consumption. Climate, too, plays a fundamental role in shaping natural ecosystems, human economies and the cultures depending on it.

Climate has been changing, affecting farming livelihoods. Climate-Change (CC) is a significant and lasting change in the statistical patterns of precipitation, temperature, wind, humidity and seasons over periods ranging from decades to millions of years. It alters ecosystems, affecting humans and livestock that rely on a given landscape for food-crops, pastures and water. Climate-Change and Variability (CC&V) is one of the greatest environmental, social and economic challenges facing humanity today and it is a phenomenon that undermines the drive for sustainable development, particularly in sub-

Saharan Africa (Tadesse, 2010). Higher temperatures eventually reduce yields of desirable crops, while encouraging proliferation of weeds and pests. Variability is an integral part of CC, in which: a change in mean climatic conditions is experienced through changes in the nature and frequency of particular yearly conditions, including extremes (Ziervogel et al., 2006). Changes in precipitation patterns increase the likelihood of short-run crop failures and long run production declines, negatively affecting local food supplies due to reduced crop productivity, livestock feed/fodder availability (FARA, 2015). The smallholders of Kalii watershed have been experiencing water shortages and drought due to unreliable and poorly distributed and unpredictable rains since the 1980s (Awuor, 2009). This pattern was consistent with projections that Kenya's vulnerable ASALs would experience an increase in the frequency and severity of droughts and significant declines in rainfall and river flows due to CC&V necessitating CSA adoption. However what is CSA?

Climate-smart agriculture is farming that sustainably increases productivity, incomes and resilience (adaptation); reduces/removes greenhouse gases (mitigation) and improves likelihood of national food-security and development goals (FANRPAN, 2013). It is an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food-security under CC. Climate-smart agriculture is designed to identify and operationalise sustainable agricultural development within the explicit parameters of CC&V (FAO, 2013). CSA contributes to the achievement of sustainable development goals by integrating the three dimensions of sustainable development (economic, social and environmental) to maximise the benefits and minimise the trade-offs by jointly addressing food-security and climate challenges (FAO, 2013). It includes proven practical techniques, such as mulching, intercropping, Conservation Agriculture (CA), crop-rotation, integrated crop-livestock management, agroforestry, improved grazing and improved water management, and innovative practices, e.g. better weather forecasting, more resilient food crops, and risk-insurance (Boto et al., 2012). CSA shares many of the practices of CA and is consistent with CA goals. Conservation agriculture as a farming approach fosters natural ecological processes to increase agricultural yields and sustainability by minimising soil disturbance, maintaining permanent soil cover, and diversifying crop rotations (Milder et al., 2011). Climate-smart agriculture has been found to increase crop yields, enhance carbon content in soils and maintain soil moisture (FAO, 2014). It puts these conditions at the heart of transformational change in agriculture by concurrently pursuing increased productivity and resilience for food-security using improved, drought-resistant and early-maturing crops (e.g. leguminous crops) while fostering mitigation where possible. Agriculture in the coming decades must feed Kenya, serve as the engine of growth and adapt to CC.

There are certain gender dimensions with regard to perception and adoption of modern innovations that exert different impacts and imbalance on men and women, as well as distinct cultural beliefs and practises (Kakooza et al., 2005). Gender differences have implications for research, extension, development outputs, innovation in terms of flexibility, responsiveness and dynamism under increasing CC&V (Leeuwis and Aarts, 2011). African agricultural innovations are patriarchal in nature. They minimise women's access to relevant resources and benefit men more than women, lessen the workload of men but increase drudgery on women and girls in agricultural production (Kumar and Quisumbing, 2012). Agricultural innovations are "workable" ideas, practices, products, or changes to processes or rules; "involve the extraction of economic, ecological, and social value from knowledge" (Asenso-Okyere et al., 2008, p.2). They play a central role in agriculture, for achieving economic, social, and environmental goals (Klerkx et al., 2009; 2012). Innovation systems are linked by exchange and production of knowledge and include policies and institutional arrangements that structure their relationships. However, despite the key-role of smallholders, they are often forgotten and overlooked, in this process (Spielman et al., 2010). Yet, for successful food-security initiatives, local innovation and technical knowledge, social-relations and cultural-norms need to be considered from the onset (Meinzen-Dick et al., 2013). The ability to innovate and the capacity to foster innovation varies greatly and relates closely to extension systems that facilitate social learning, incorporate feedback loops, and iterative interactions (Davis et al., 2008).

This paper discusses the role of gender and innovations in the adoption of resilient farming systems among smallholders, the resource-poor women and men within Kalii Watershed, Makueni County, Kenya under CC&V. Makueni is characterised by a rapidly growing population, water scarcity, falling food production and low-resilience to CC&V (MoPD, 2015). The combined effects of CC and rapid-population growth are increasing food insecurity, environmental degradation, and poverty-levels in the county. The general objective of the study was to contribute to better understanding of improved food and nutrition security among the hunger-prone people of Kalii. It examined labour, land, livestock, natural resource management (NRM), gender, social, innovations, education, economic and environmental impacts, and adoption of technologies prioritised by different participating gender-cadres in the watershed, for improved livelihoods. Kalii watershed is part of Kenya's arid and semi-arid lands (ASALs) that occupy 89% of the country and are home to about 36% (16 million) of the population, 70% of the national livestock herd and 90% of the wild game that supports the country's tourism industry (MoPD, 2015). Low rainfall in ASALs makes farming a challenge for resource-poor households, the smallholders. Climate-change and variability, decreasing farm-size, crop yield and household (HH) incomes as well as degradation of land, tree-cover and water-resources exacerbates the situation (Ngugi and Nyariki, 2005). CC&V affects the different gender-cadres due to frequent crop failures and frequent loss of livestock during droughts (Lobell et al., 2011). Frequent crop failures affect women more than men, as women mostly tend crops and own small livestock such as poultry, while men own large livestock such as cattle goats and sheep.

This study was justified because the absolute poverty-levels were as high as 64.3% (in 2012) but were projected to drop to 62% (mid-term 2015) and 60% (end-term 2017) in Kalii (MoPD, 2013). Hunger and malnutrition negatively impact women and children (MoPD, 2013). Gendered inequalities in resource use, ownership and on-farm decision-making power were critical challenges to food-security initiatives in Kalii watershed. Climate-change and variability was negatively affecting HHs in Kalii watershed and the IPCC projected a 2°C rise in temperature in the ASALs over the next 15 years (IPCC, 2007). New strategies were required to increase smallholder adoption of resilient farming systems that have the flexibility to deal with stresses and disturbances as a result of CC&V, while retaining the same basic structure and capacity for self-organisation by incorporating gender-issues (Ifejika-Sperenza, 2010).

2 Methodology

2.1 Description of the study site

Kalii watershed has a total land area of 17,811.2 hectares (ha) and is located in Kibwezi West sub-county, Makindu Ward, Makueni County. Kibwezi West sub-county has four administrative locations and 6 sub-locations. It is situated in the semi-arid lands of Eastern Kenya. Makueni County is largely ASAL and usually prone to frequent droughts. The study was conducted in three sub-locations of Mitendeu, Kalii and Kyale Makindu Ward (Figure 1). The Ward had a total human population of 18,382 (7,240 men, 7,454 women and 3,638 (1,746M and 1,892F) children (MoDP, 2013). Kalii watershed is located within latitude: 2° 02' 45.6" S and 2° 13' 59.1" S; longitude: 37° 57' 39.9" E and 37° 43' 25.1" E and an altitude of about 600 m above sea level. There were 3,854 HHs in the Ward and most of these HHs were classified as resource-poor (MoPD, 2015). The Kalii watershed received bi-modal rainfall, the long rains in March/April and short rains in November/December. The latter was more effective and reliable. The amount received ranged from 300-400mm annually. Figure 2 shows the status of rainfall received in the study sites from 1979-2000. Relative humidity was high due to evapo-transpiration rates throughout the years with an average of 85% over the years. Temperatures were generally high, February, March and October being the hottest months over the years. This worsened the dry conditions, the sun’s heat during the dry periods from May-October (MoDP, 2015).

Figure 1 Study site (red marks are the households selected)

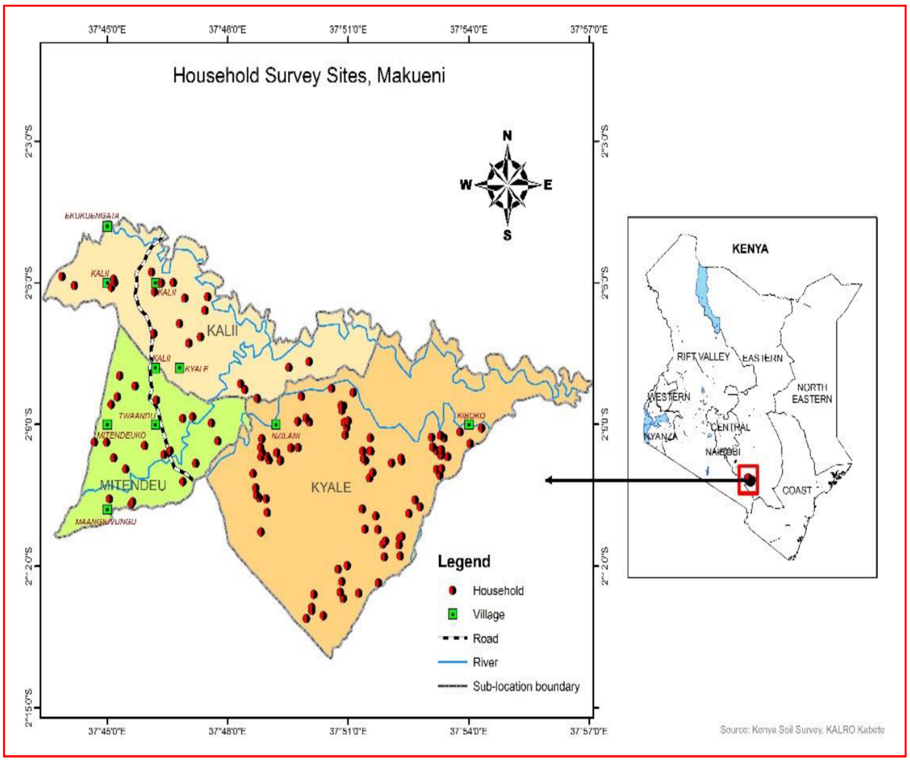
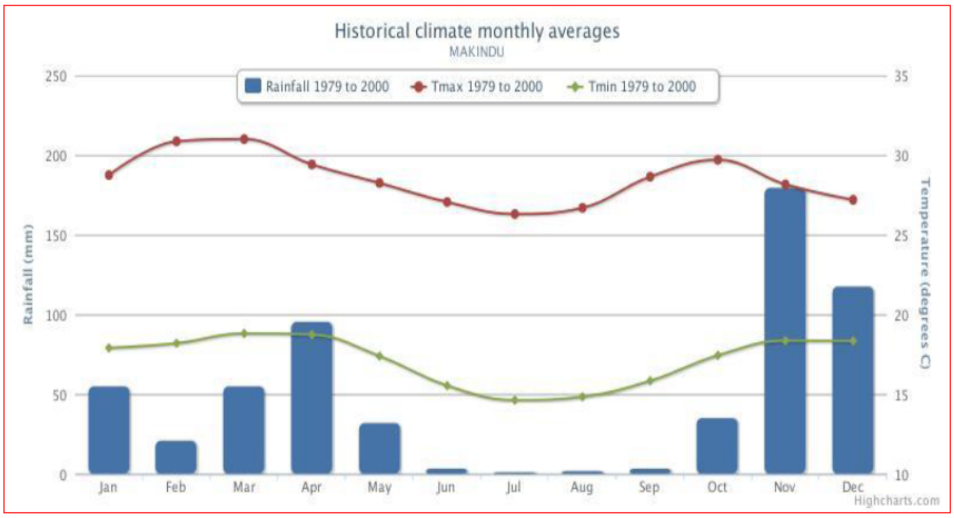


Figure 2 Mean monthly rainfall and temperature conditions across the years, 1979–2000 (Source: Kiboko Weather Station)



2.2 Sampling techniques

The study applied purposive, stratified and multistage sampling techniques (Lynn, 2009). The watershed was purposively selected. However, in the multistage sampling, first, three sub-locations out of six were randomly selected. Second, 150 HHs were randomly selected from 3,854 registered HHs in the watershed, obtained from the County Agriculture offices. These HHs were randomly picked (selection without replacement) from 30 villages (one to six respondents from each village depending on the weights assigned) that constituted the three sub-locations studied. The 30 villages as per availed sampling frames had different populations, so the proportionality rule was applied using the formula:

$$P_i = \frac{a_i}{\sum_{i=1}^{n} h} * \frac{150}{VSL}$$

where; ***i*** = individual village in a sub-location, ***P*** = proportion of the HHs in the sample size from village *i*; ∑ = is the summation symbol; **α** = the confidence levels used in the analysis (at 1, 5 and 10 % respectively); ***n*** = total number of villages per sub-location; ***h*** = total number of HHs in *n* villages per sub-location, ***150*** = the sample size from the watershed and ***VSL*** = the number of villages per sub-location.

2.3 Econometric models

Equations (1) and (2) were used in the multinomial and multiple linear regressions respectively:

$$\Pr(Y = 1 - 15) = \frac{e^{x(b1)}}{e^{xb(1)}} + e^{xb(2)} + e^{xb(3)} + \ldots\ldots\ldots + e^{xb(15)} \quad (1)$$

where Pr (Y = 1), Pr (Y = 2), Pr (Y = 3)…… Pr (Y = 15) are the probabilities of a HH selling their produce to a seed-company, *group, broker and consumer;* x(1), x(2), x(3), …….., x(16) are the independent variables of the agricultural infrastructure and institutions variables; (b1), (b2), (b3), ………, (b15) are the unknown coefficients for the agricultural infrastructure and institutions variables; $e^{xb(1)}$, $e^{xb(2)}$, $e^{xb(3)}$,….., $e^{xb(15)}$ are the exponential values of the coefficients of the independent agricultural infrastructure and institutions variables. In order to identify the multinomial model, one of the logits in each set was set to zero.

$$Y_P = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots + \beta_k X_k + u \quad (2)$$

where Y_P = the leguminous crops (Cowpeas or Green grams) output by a HH; β_0, β_1, β_2...β_k are the unknown coefficients; $X_{1....}X_k$ are the agricultural infrastructure and institutions variables; u is the error term (Vittinghoff et al., 2005; Hoffmann, 2003; Schwab, 2002).

2.4 Data collection, source and types

The study collected and used both primary (principal) and secondary (ancillary) data, which were both quantitative and qualitative. Principal data were collected during formal surveys from the 150 randomly selected households/respondents and Focus Group Discussions (FGDs). A semi-structured questionnaire was used to capture principal data from the surveys. Four FGDs were conducted (male-only; female-only; youths-only and a mixed-one, involving 12 participants in each, a total of 48 participants), in March 2015. Six recruited and trained enumerators, one supervisor and 10 village elders were involved in the six-day formal surveys. The team took two days per each sub-location and each of the six enumerators administered 25 questionnaires. Ancillary data was through desk literature reviews of various relevant documents and Regional Climate Information Portal for Makindu and Kiboko areas, the observed climate data for over 20 years. The information collected was on agricultural infrastructure and institutional aspects pertaining to pulse production and marketing for improved livelihoods.

2.5 Data analyses

The collected data were cleaned on daily basis and passed to recruited and trained data clerks who entered it into Microsoft Excel. The data was later imported into Statistical Package for Social Sciences (SPSS) Version 21, STATA and INSTAT+ Computer Packages. Analyses encompassed multinomial and multiple linear regressions, descriptive statistics and gender analyses. $INSTAT^+$ was used to analyse the historical climate data to generate the maps and predict the trends for the next 20 years. Multiple regressions involved two-stage least squares (2SL) on pulse production and ordinary least squares (OLS) on pulse marketing. Eventually the 150^{th} questionnaire was discarded in the final analyses for being an outlier.

3 Results

3.1 Household and farm characteristics

The respondents in the 149 HHs comprised (62%) females (F), (28%) males (M), and youth 10% (6F and 4M). Most (75%) were male-headed, 15% were female-headed and

10% were youth-headed (53% F and 47% M). Disaggregated by gender, HH mean size was six for M, five for F and five for youth (Y). The mean age of the HH head was 49 years, with a minimum of 19 and maximum of 120 years, an age that was no longer economically productive. However, the most productive age was 19-49 years. On gender basis, the mean age of HH heads was 68 years for M, 70 years for F, and 30 years for Y. About 74% of all the HH heads (HHHs) had attained primary and secondary school and 3% tertiary education level.

The mean land size holdings in Kalii watershed was about 8.0 hectares (ha) with a standard deviation of 14.56, ranging from a minimum of 0.4 ha to a maximum of 200.0 ha (one HH). Majority of the HHs (70%) owned 2 ha of land. The computed means of the land being cultivated and left fallow were 2.8 and 6.08 ha, however, 0.6 and 0.4 ha were the commonest land sizes being cultivated and left fallow respectively (Table 1).

Table 1 Land ownership and use in Kalii watershed

Land status	*Sizes of land holdings (ha)*							
	< 4.0	*4.004–* 8.0	*8.004–* 12.0	*12.004–* 16.0	*16.004–* 20.0	*20.004–* 24.0	≥24.004	*Total*
Land owned individually (*n*)	100	20	5	4	6	3	5	143
%	67.1	13.4	3.4	2.7	4.0	2.0	3.4	96.0
Cultivated (*n*)	110	15	5	2	4	1	2	139
%	73.8	10.1	3.4	1.3	2.7	0.7	1.3	93.3
Fallow (*n*)	118	10	3	2	5	1	3	142
%	79.2	6.7	2.0	1.3	3.4	0.7	2.0	95.3
Land rented in (*n*)	30	4	2	0	0	0	0	36
%	20.1	2.7	1.4	0	0	0	0	24.2
Cultivated (*n*)	22	2	1	0	0	0	0	25
%	14.8	1.3	0.7	0	0	0	0	16.8
Fallow (*n*)	12	1	1	0	0	0	0	14
%	8.0	0.7	0.7	0	0	0	0	9.4
Land rented out	6	0	2	2	0	0	0	10
%	4.1	0	1.3	1.3	0	0	0	6.7
Cultivated (*n*)	4	0	0	0	0	0	0	4
%	2.7	0	0	0	0	0	0	2.7

Source: ASARECA water productivity project (AWP) baseline 2015.

Notes *n* = sample size, ha= hectares i.e.1ha= 2.5 acres

3.2 Agricultural production and constraints

The households in the watershed were involved in the production of food and cash crops, and livestock. There were a number of crops produced but this study concentrated on improved cowpeas, green grams and mangoes that were being promoted by Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) Agricultural Water Productivity Project (AWP), in the watershed. Crop yields were low, about 900kg/ha of improved cowpeas and 450kg/ha of improved green grams per season among most HHs. There were different types of livestock owned and kept in varying numbers by most of the HHs that included: cattle (mainly local-breeds), sheep and goats (shoats), chicken, donkeys, and other minor livestock types. The most important livestock types kept by the HHs were; local chicken (84.0%); local shoats (83.0%) and local cattle (59.0%). The respondents identified a number of agricultural constraints faced in the watershed as summarised in Table 2. There were 11 crop constraints identified that included: CC&V, input costs, pests and diseases, inadequate improved seeds, water availability, marketing, prices, quality of produce, processing difficulties, storage and post-harvest losses whose values ranged from 8–95%. There were 13 livestock constraints identified, which included: high-costs of inputs, limited access to services, lack of improved breeds, vectors and diseases, low water availability and soil fertility, lack of grazing land, labour, equipment, improved pastures, land tenure and small land holdings whose values ranged from 25–75%. The farmers subjectively ranked these constraints either as high or low in regard to their impacts to agricultural production.

Table 2 Agricultural constraints faced

Crop constraints	*%*	*Rank*	*Livestock constraints*	*%*	*Rank*
Climate-change and Variability	95	High	High costs of inputs (feed and drugs)	75	High
High Input costs	80	High	Limited access to services and inputs	69	High
Pests and diseases	66	High	Lack of improved breeds	65	High
Low availability of water	60	High	Vectors and diseases	63	High
Inadequate improved seeds	58	High	Low availability of water	50	High
Setting of prices	40	High	Lack of grazing land	47	High
Not organised collectively	35	High	Low quantity of pastures	38	High
Low market prices	30	High	Land Tenure	54	Low
Difficulties in processing	10	Low	Small land holding	50	Low
Low quality of produce	9	Low	Low soil fertility	46	Low
Storage/post-harvest losses	8	Low	Lack of labour force	30	Low
			Lack of equipment	28	Low
			Lack of improved varieties	25	Low

Source: AWP baseline 2015;

3.3 *Climate-change and variability*

The responses from the FGDs and interviews affirmed the signs of CC&V in the study sites were evident. Table 3 summarises the evidences provided on; climate in 2015 versus that 30 years ago; precipitation; temperatures; wind speed; sun heat intensity; frequency of droughts, drying up of rivers; crop and livestock pests and diseases; frequency of hunger and human diseases incidences. Figure 3 shows the trends for total rainfall in the study sites from 1990-2008, indicating whether the climate was ‘good’ or ‘bad’ and whether the other elements had increased/decreased, remained constant or the respondents were unsure. The climate was ‘bad’ (85.0%) now as opposed to three decades ago when it was ‘good’ (89.0%) The increase in these elements ranged from 77-97%. While Figures 4-6 show the key projections in the study sites under representative concentration pathways (RCP), RCP 8.5 emission scenarios, the pathway with the highest greenhouse gas emissions, for total rainfall, mean dry spell duration and maximum temperatures for 2017-2037 respectively. These again would either, increase, decrease or remain constant.

Table 3 Perceptions of respondents on climate-change and variability in the three sub locations of Kalii watershed

Variable	*Ranking*	*Mitendeu (% of n=50)*	*Kalii (% of n=50)*	*Kyale (% of n=49)*	*Total (n=149)*
Climate in 2015	good	6.5	6.0	6.4	5.9
	bad	85.0	86.0	85.4	85.1
	very bad	7.6	7.0	7.2	7.4
	constant	0.9	1.0	1.0	1.6
Climate 30 years ago	good	84.2	88.0	89.4	88.6
	bad	10.2	11.0	9.2	10.0
	very bad	1.3	0.0	0.2	0.6
	constant	1.3	1.0	1.2	0.8
Rainfall	increased	4.6	3.0	4.8	4.4
	decreased	91.2	96.0	94.2	93.6
	constant	4.2	1.0	1.0	2.0
Temperature	increased	96.8	97.0	96.0	96.8
	decreased	0.0	2.0	3.2	1.8
	constant	2.2	1.0	0.8	1.4
Wind	increased	97.2	98.0	96.4	97.3
	decreased	1.8	1.0	2.6	1.9
	constant	0.0	0.0	0.0	0.0
	Not sure	1.0	1.0	1.0	0.8
Sun heat intensity	increased	96.0	97.0	95.5	96.4
	decreased	2.0	1.0	3.5	2.2
	constant	2.0	1.5	0.0	1.3
	Not sure	0.0	0.5	1.0	0.1
Droughts frequency	increased	96.8	97.0	95.5	96.5
	decreased	1.6	2.0	3.5	2.4
	constant	1.6	0.0	0.0	0.5
	Not sure	0.0	1.0	1.0	0.6
Drying up of rivers	increased	97.2	98.0	96.0	97.3
	decreased	1.8	1.0	2.0	1.7
	constant	0.0	0.5	1.0	0.5
	Not sure	1.0	0.5	1.0	0.5
Crop and animal pests and diseases' incidences	increased	90.5	94.0	92.0	92.3
	decreased	6.5	5.0	7.0	6.3
	constant	1.0	0.0	0.0	0.2
	Not sure	2.0	1.0	1.0	1.2

Table 3 Perceptions of respondents on climate-change and variability in the three sub locations of Kalii watershed (continued)

Variable	*Ranking*	*Mitendeu (% of n=50)*	*Kalii (% of n=50)*	*Kyale (% of n=49)*	*Total (n=149)*
Frequency of hunger	increased	96.3	98.0	97.0	97.4
	decreased	2.5	2.0	2.0	2.2
	constant	1.2	0.0	1.0	0.4
Human diseases incidences	increased	76.4	78.0	77.0	77.3
	decreased	11.1	10.5	12.0	11.2
	constant	10.2	9.5	10.0	9.8
	Not sure	2.3	2.0	1.0	1.7

Source: AWP baseline 2015;

Notes: the rankings of good, bad, very bad, constant and not sure as perceived by focus group discussants, key informants and questionnaire respondents; Good—Abundant rainfall accompanied by good farm harvests, improved rains and crop yields enough for subsistence purposes; Bad—unreliable/unpredictable rainfall, droughts, poor or little farm harvests, drying rivers, food insecurity for both humans and livestock, persistent droughts, increased winds; Very bad—intense sun's heat, high temperatures, erratic/unpredictable rainfalls, poor crop harvests, rampant frostbite, prolonged/persistent droughts for up to 3-5 years, food insecurity, drying rivers; Constant—no comparable observable change in climate; Not sure—no perception on the changes in the climate in the study sites.

Figure 3 Trends of the total seasonal and annual variation of rainfall over Makindu, 1990-2008 (Source: Kiboko Weather Station)

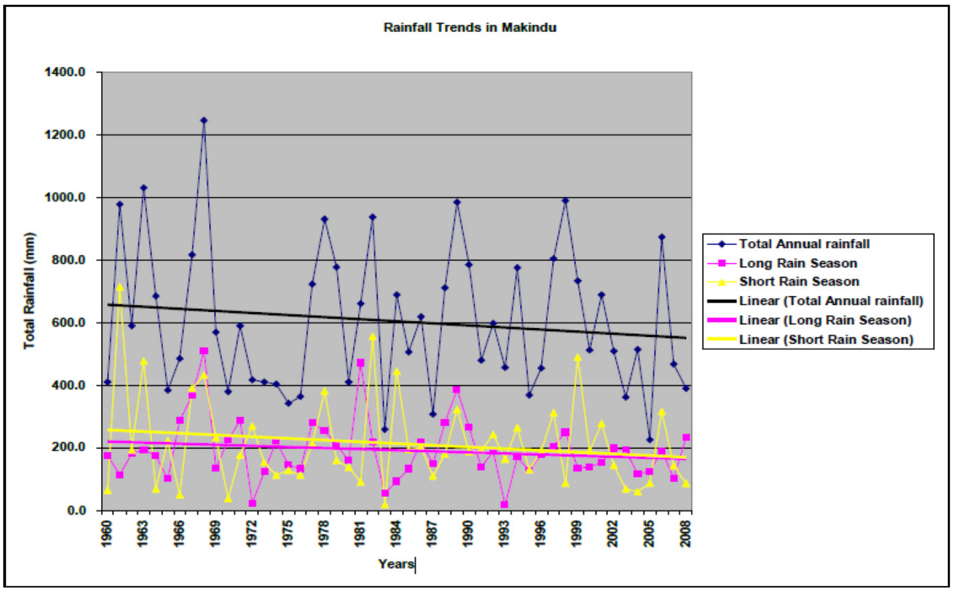


Figure 4 Projected total monthly rainfall (2017-2037) in Kiboko under RCP 8.5 emission scenarios

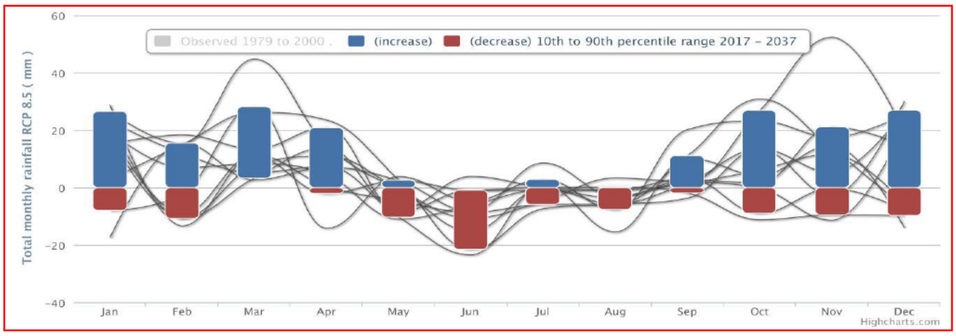


Figure 5 Projected mean dry spell duration 5 in Kiboko under RCP 8.5 emission scenarios

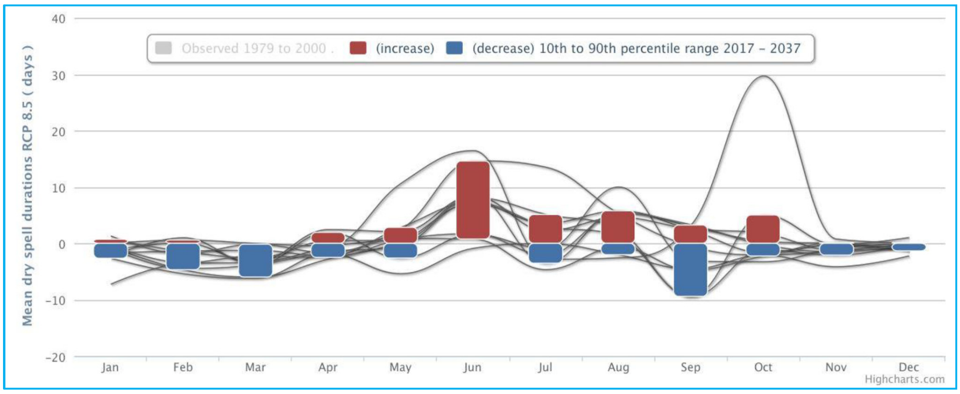
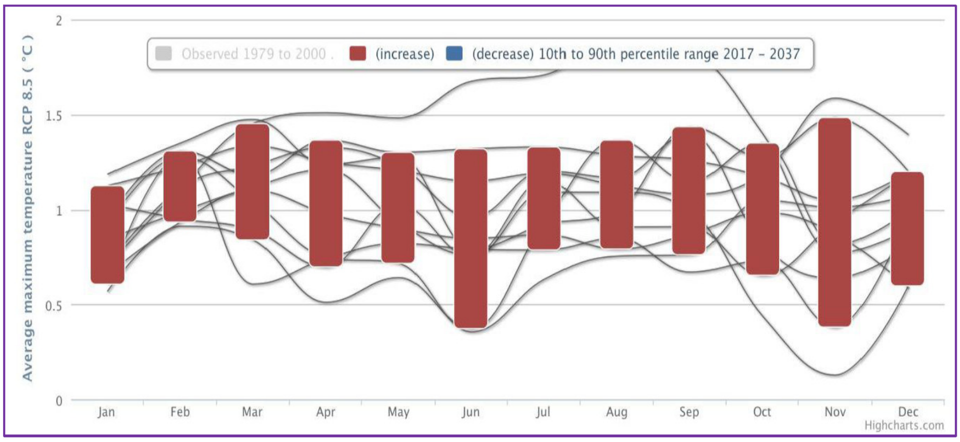


Figure 6 Projected mean maximum temperature (2017-2037) in Kiboko area under RCP 8.5 emission scenarios



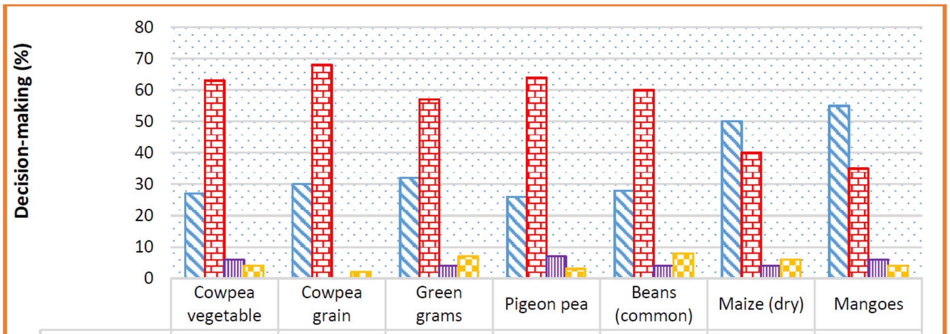
3.4 Climate-smart agriculture innovations

There were a number of climate-smart technologies/innovations adopted and applied within the watershed, as affirmed by the FGDs and interviewees. The technologies included: terraces/trenches (70.8%), water harvesting (56.7%), irrigation (42.0%), Zai pits (25.6%), tied-ridges (43.4%), mulching (48.6%); animal manure/compost (62.5%), agro-forestry (18.8%), cover crops (48.2%), crop rotation (53.3%), intercropping (61.6%), Rhizobia inoculation (21.2%); row planting (44.8%), seed priming (35.9%), and improved crop varieties (37.5%).

3.5 Decision-making

The findings of the baseline and FGDs showed that in general all the gender cadres shared in decision-making. Decisions made by adult male ranged from 26-55%; adult females 35-68%; male youths 0-7% and female youths 2-8%. The decisions were made on a number of crops (food and cash) and livestock (both major and minor ones). There were differences on the decision-making as highlighted in Figure 7.

Figure 7 Decision-making on production of crops by gender; Notes: The crops grown were mainly research improved crops that were drought resistant and early maturing to cope with CC&V. These were crops that were being promoted under the ASARECA Agricultural Water Productivity Project (AWP). The project did not promote livestock and that is why it was never included in the regressions. Gender categorisation is based on age so you are either an adult of a youth and not both



	Cowpea vegetable	Cowpea grain	Green grams	Pigeon pea	Beans (common)	Maize (dry)	Mangoes
Adult male	27	30	32	26	28	50	55
Adult female	63	68	57	64	60	40	35
Male youth	6	0	4	7	4	4	6
Female youth	4	2	7	3	8	6	4

3.6 Multinomial logit regression results

There were four market outlets Seed Company (base category), group, broker and consumer for the farm products. The buyer of the improved pulses and livestock was therefore of three unordered categories that constituted the response variable in regard to gender and CSA. The results show the probability of the smallholders selling their improved cowpeas and green grams produce to one of the categories, given the education of the household head, age, family and land sizes, gender, available labour, decisions made on asset and proceeds' use, asset disposal, sources of information on production, CC&V and NRM, marketing and distance to the market as the predictor variables. Table 4 summarises results on multinomial logit regression analysis regarding the choices HHs made on disposal of produce and the destinations of the commodities by the different smallholders/HHs. It shows that the probabilities of smallholders selling to any of the markets differed as indicated by the *p*-value for each term which tested the null hypothesis that the coefficient was equal to zero (no effect). A low *p*-value (< 0.05) indicated that the null hypothesis could be rejected. In other words, a predictor of a low *p*-value was likely to be a meaningful addition to one's model because changes in the predictor's value were related to changes in the response variable under the prevailing CC&V in regard to gender and CSA.

Table 4 Parameters and the rrr estimates from the multinomial logit model

Buyer	*Variables*	*rrr*	*P-values*	*z*	*Odds ratio (%)*
Seed Company	*Base Category*				
Group	HH-size	2.767011 (1.02994)	0.006*	2.73	177
	Land-size	2.447514 (1.10180)	0.047*	2.69	145
	Available HH labour	1.060193 (0.01266)	0.014*	2.53	147
	Decision-making on asset use	0.048938 (0.12422)	0.024*	–2.26	95
	Decision-making on asset disposal	0.750727 (0.05737)	0.000*	–3.75	25
	Decision-making on benefits use	0.642951 (0.11320)	0.012*	–2.51	36
	Information source on production	0.168027 (0.09222)	0.001*	–3.25	84
	Information source on CC&V	1.157182 (0.08262)	0.010*	–3.34	86
	Information source on NRM	1.030193 (0.01266)	0.015*	2.42	173
Broker	Age of HHH	1.034196 (0.00792)	0.000*	4.39	3
	Gender of HHH	1.654221 (0.08446)	0.001*	–2.84	38
	Education of HHH	1.023131 (0.12559)	0.041*	2.04	23
	Land-size	0.583733 (0.05167)	0.000*	–6.38	46
	Decision-making on benefits use	0.642951 (0.11320)	0.012*	–2.51	36
	Information source on CC&V	1.050213 (0.00188)	0.013*	2.80	7
	Information source on marketing	0.048938 (0.12422)	0.024*	–2.26	95
	Distance to market	0.290913 (0.07150)	0.000*	–5.02	71

Table 4 Parameters and the rrr estimates from the multinomial logit model (continued)

Buyer	*Variables*	*rrr*	*P-values*	*z*	*Odds ratio (%)*
Seed Company	*Base Category*				
Consumer	Age of HHH	1.030182 (0.01288)	0.014*	2.44	10
	Gender of HHH	0.033612 (0.11341)	0.025*	–2.34	36
	Education of HHH	1.032188 (0.12434)	0.034*	2.26	25
	HH-size	0.750727 (0.05737)	0.000*	–3.75	24
	Land-size	0.642951 (0.11320)	0.012*	–2.51	36
	Decision-making on asset use	0.033138 (0.13328)	0.016*	–2.54	40
	Decision-making on asset disposal	0.048938 (0.12422)	0.024*	–2.26	92
	Decision-making on benefits use	0.711302 (0.04826)	0.001*	–3.66	28
	Information source on production	0.561860 (0.11480)	0.011*	–2.86	34
	Information source on marketing	1.060920 (0.01646)	0.013*	2.77	12
	Distance to market	0.168027 (0.09222)	0.001*	–3.25	84

Source: AWP baseline, 2015; Reference category = seed-company; Standard errors (figures in parenthesis), *0.05 Confidence level; n = 149; Pearson chi 2(3) = 17.5125; P = 0.0001; Fisher's exact = 0.546 n = 149].

Notes: HH= household; HHH = household head; CC&V = climate-change and variability; NRM = natural resource management; rrr= relative risk ratios.

3.7 Linear regression results

The results from multiple linear regressions on the production and marketing of leguminous crops (improved cowpeas and green grams) in the watershed are summarised in Tables 5, 6, 7 and 8. Tables 5 and 6 show the two marginal analysis regressions conducted where improved cowpeas and green gram outputs (CPO) and green grams (GGO) were the dependent variables. Out of 16 independent variables analysed on the production of improved cowpeas, 10 were found to be significant at either 1($p<0.01$), 5($p<0.05$) or 10 $p<0.10$) % respectively. The percentages of significant improved cowpeas factors ranged from 19 to 65% as per the coefficients (β). These provided the necessary information to predict the 16 independent variables from the dependent variable CPO. They also served as determinants in deciding whether the 16 independent variables contributed statistically and significantly to the model based on the *t*-ratios. The results on improved green grams analysis showed that out of 16 independent variables, seven (7) of them were statistically significant and contributed significantly to the model in which GGO was the dependent variable. The values for the significant coefficients ranged from 19 to 48%. Similarly, the results of marginal analyses on the marketed surpluses of cowpeas and green grams are presented in Tables 7 and 8, where the annual output of improved cowpeas in kilograms/ha (ANNCPOKG) and annual output of improved green grams in kilograms/ha (ANNGGOKG) were the dependent variables respectively and there were 13 dependent variables that were analysed under each of the two regressions. The results for improved cowpeas showed that out of 13 variables, 11 were statistically significant at either 1(p<0.01), 5(p<0.05) or 10(p<0.10) % respectively. The result for improved green grams, 10 were statistically significant at the same confidence levels. The values for the significant coefficients ranged from 13 to 49% for improved cowpeas and from 12 to 40% for improved green grams. The R^2 values that indicated how much of the total variation in the dependent variables, annual outputs in kg/ha of the two improved crops (cowpeas and green grams) could be explained by the 13 independent variables under each regression analyses and the values were about 95 and 96%, respectively.

Table 5 Regression analysis (2SLS) of the factors and their use efficiency in the production of cowpeas

Variable	*Improved Cowpeas*	
	B	*t-ratio*
CONSTANT	60.038	1.987*
Dependent variable: CPO		
Independent variables:		
AGEHHH	0.015	0.172
HHSIZE	–0.022	–0.694
EDUCHHH	–0.117	–1.334
LNDUCPHA	0.572	6.192***
AVHHLABR	0.189	1.989*
AVGHLABR	–0.136	–2.245**
USEICPSD	0.282	2.999***
USEOMANR	0.136	1.602
INCOMECP	0.488	3.903***
OFFFRINC	–0.026	–0.268
SINFRCCV	0.648	2.888*
SINFRNRM	0.564	2.776*
SINFRPSD	–0.483	–1.934*
SINFRCRS	–0.397	–2.619*
SINFMKTG	–0.054	–0.624
COLLACTN	0.612	3.744*

Source: AWP baseline 2015; *** significant at 1% (p<0.01) level of significance (Los), ** significant at 5% (p<0.05) Los, *significant at 10 % (p<0.10) Los, otherwise insignificant.

Notes: CPO = cowpeas output; AGEHHH= age of household head; HHsize = size of the household; EducHHH = education of the household head; AVHHLABR = available family labour; AVGHLABR= average hired labour; LNDUCPHA = area under the improved cowpeas in hectares; USEICPSD = use of improved cowpeas seeds; INCOMECP = income from improved cowpeas; OFFFRINC= off-farm income; SINFRCCV = source of information on CCV; SINFRNRM = source of information on NRM; SINFRPSD = source of information on pests and diseases; SINFRCRS = source of information on crop storage; SINFMKTG= source of information on marketing; COLLACTN = collective action.

Table 6 Regression analysis (2SLS) of the factors and their use efficiency in the production of green grams

Variable	*Improved green grams*	
	β	*t–ratio*
CONSTANT	–5.290	–0.285
Dependent variable: GGO		
Independent variables:		
AGEHHH	0.003	0.028
HHSIZE	0.168	1.784*
EDUCHHH	0.081	1.234
LNDUGGHA	0.188	2.284**
AVHHLABR	–0.162	–1.166
AVGHLABR	0.006	0.524
USEIGGSD	–0.086	–1.228
USEOMANR	–0.096	–1.265
INCOMEGG	–0.044	–0.546
OFFFRINC	–0.018	–0.236
SINFRCCV	0.478	1.608*
SINFRNRM	0.372	1.408*
SINFRPSD	–0.287	–1.620*
SINFRCRS	–0.226	–1.854*
SINFMKTG	–0.084	–1.068
COLLACTN	0.218	1.848*

Source: AWP baseline 2015; *** significant at 1% ($p<0.01$) level of significance (Los), **significant at 5% ($p<0.05$) Los, *significant at 10% ($p<0.10$) Los, otherwise insignificant.

Notes: GGO = improved green grams output; AGEHHH= age of household head; HHsize = size of the household; EducHHH = education of the household head; AVHHLABR = available family labour; AVGHLABR= average hired labour; LNDUGGHA= area under the improved green grams in hectares; USEIGGSD = use of improved green gram seeds; USEOMANR= use of manure; INCOMEGG = income from improved green grams; OFFFRINC= off-farm income; SINFRCCV = source of information on CCV; SINFRNRM = source of information on NRM; SINFRPSD = source of information on pests and diseases; SINFRCRS = source of information on crop storage; SINFMKTG= source of information on marketing; COLLACTN = collective action.

Table 7 Regression analysis (OLS) of the determinants of marketed improved cowpeas marketed surplus

Commodities	*Improved Cowpeas (CP)*	
Factors	*Coefficient*	*t-ratio*
INTERCEPT	–68.122	-4.776***
Dependent variable: ANNCPOKG	4.296	16.286***
Independent variables:		

Table 7 Regression analysis (OLS) of the determinants of marketed improved cowpeas marketed surplus (continued)

Commodities	*Improved Cowpeas (CP)*	
Factors	*Coefficient*	*t-ratio*
AGEHHH	–0.006	–0.055
HHSIZE	0.186	1.984*
EDUCHHH	0.147	1.894*
LNDUCPHA	–0.488	–2.867*
HHCONSCP	0.085	0.912
OXENOWND	0.198	2.968***
KNPSCKSP	0.140	1.966*
OWSTRFAC	–0.038	–1.880*
AVHILABR	–0.126	–2.354**
QTOFHHCN	–0.194	–2.744**
QTGNAYKG	–0.413	–8.165***
QTRNSDKG	–0.444	–6.019***
MRKTUNTP	0.186	3.268***
Adjusted *R*-Squared (R^2)	0.948	

Source: AWP baseline, 2015; ***significant at 1% ($p<0.01$) level of significance (Los), **significant at 5% ($p<0.05$) Los, *significant at 10% ($p<0.10$) Los, otherwise insignificant.

Notes: ANNCPOKG = annual output of improved cowpeas in kg/ha; AGEHHH= age of household head; HHsize = size of the household; EducHHH = education of the household head; LNDUCPHA = area under the improved cowpeas/ha; HHCONSCP = household consumption of cowpeas; OXENOWND = number of oxen owned; KNPSCKSP = knapsack sprayer owned; OWSTRFAC = own storage facility; AVHILABR = available hired labour; QTOFHHCN = quantity of household consumption; QTGNAYKG = quantity given away in kgs; QTCPRSKG = quantity retained as seed in kgs; MRKTUNTP = market unit price.

Table 8 Regression analysis (OLS) of the determinants of marketed improved green grams surplus

Commodities	*Improved Green grams (GG)*	
Factors	*Coefficient*	*t-ratio*
INTERCEPT	3.564	0.664
Dependent variable: ANNGGOKG	1.665	7.380***
Independent variables:		
AGEHHH	–0.016	–0.148
HHSIZE	0.019	0.320
EDUCHHH	0.162	1.788*
LNDUGGHA	–0.018	–2.860***
HHCONSGG	–0.182	–2.876**
OXENOWND	0.221	2.966***
KNPSCKSP	0.130	1.824*

Table 8 Regression analysis (OLS) of the determinants of marketed improved green grams surplus (continued)

Commodities	*Improved Green grams (GG)*	
Factors	*Coefficient*	*t-ratio*
OWSTRFAC	–0.036	–1.820*
AVHILABR	–0.138	–2.464**
QTOFHHCN	–0.396	–47.468***
QTGNAYKG	–0.124	–14.266***
QTRNSDKG	–0.130	–16.668***
MRKTUNTP	0.011	0.647
Adjusted *R*-Squared (R^2)	0.959	

Source: AWP baseline, 2015; *** significant at 1% ($p<0.01$) level of significance (Los), ** significant at 5% ($p<0.05$) Los, * significant at 10% ($p<0.10$) Los, otherwise insignificant.

Notes: ANNGGOKG = annual output of improved green grams in kg/ha; AGEHHH= age of household head; HHsize = size of the household; EducHHH = education of the household head; LNDUGGHA= area under the improved green grams in ha; HHCONSGG = household consumption of improved green grams; OXENOWND = number of oxen owned; KNPSCKSP = knapsack sprayer owned; OWSTRFAC = own storage facility; AVHILABR = available hired labour; QTOFHHCN = quantity of household consumption; QTGNAYKG = quantity given away in kgs; QTCPRSKG = quantity retained as seed in kgs; MRKTUNTP = market unit price.

4 Discussion

4.1 Household and farm characteristics

The results of this study have clearly indicated there was CC&V in the watershed and it was having negative impact on the different gender cadres and agricultural innovations. The results of this study compare well with other studies such as GoK (2014) on HHs and farm characteristics in Makueni County and there were no significant statistical differences pertaining to gender cadres participation in decision-making, age, farm and family sizes. The land ownership and use varied among gender cadres and uses. The efforts to improve livelihoods in Kalii should target HHs owning 4.0 ha and below because they were the majority (Table 1). Size of land holding has implications on water management and technologies being involved. It was generally observed that to properly manage conservation issues on large land holdings was usually a difficult task. Knowledge on land use was important for monitoring its use over time hence extension staff needed to educate the smallholders in this respect. The Makueni County government agents, other key stakeholders and development partners working in Kalii should guide smallholders on proper and improved use of the land. This was because food and nutrition security was a serious concern in the watershed.

4.2 Agricultural production, marketing, incomes and food-security

Agricultural production is the major occupation and source of food and income for HHs in the study sites. Different crops were grown within the study sites; however, the main ones were: improved green grams and cow peas, pigeon peas, maize (dry), beans and mangoes (Figure 7). This study's analysis however, zeroed in on two improved pulse varieties (cowpeas and green grams) and one fruit tree (mangoes), crops that were being promoted by the AWP. This was because depressed rains in the lower part of the county (where the study was based) hardly sustained the staple food crops (maize and beans) leading to frequent crop failures. Unfortunately, the traditional crops (sorghum, millet, cassava and sweet potatoes), which were drought-tolerant had largely been abandoned (MoPD, 2013). Irrespective of this, the watershed had potential for horticultural crops and major fruit trees such as mangoes, pawpaw and oranges. Grafted mangoes were vastly gaining momentum due to the high demand and favourable conditions especially in Kyale sub-location where simple irrigation was being applied.

The marketing of agricultural products was an activity usually undertaken by smallholders in order to meet certain obligations. The prices differed among the markets and largely depended on whether the markets were farm-gate or nearest markets within the study sites. There were a few HHs that marketed the majority of the key crops. The most important crops marketed by most HHs were cowpeas, green grams and mangoes. Improved green grams and cowpeas grains normally fetched KES 60-100/ kg while mangoes sold at KES 15-30 each. Different livestock types were marketed and fetched different prices in the markets. At the farm-gate, local cattle fetched a mean price of KES 20,000/head. In the nearest markets, the prices ranged from KES 2,000 to about KES 30, 000/head with a mean price of KES 18,000/head. The study found that not all gender cadres benefitted equally from the marketing of the produce and livestock proceeds, women and youths gained less than men because most livestock belonged to men. This concurs with the findings of a study by Beuchelt and Badstue (2013), which shows that women smallholders often lost control over the market niches, resources and products they traditionally managed. Once those resources and products became lucrative, men often took over the production and marketing, even of traditional women's crops. Selling of agricultural produce and livestock served as a major source of HH income. However, additional incomes were from salaried and farm wages, businesses operated and remittances from relatives. Income and food-security were interrelated and food insecurity was a problem in the watershed because the majority of the sampled HHs did not have adequate food to feed their families over the past 12 months during the year 2014. These findings concur with those of GoK (2014), a HH survey on Makueni County in 2013, which shows that the overall proportion of households that did not have enough food to meet their needs was 75%. At least 74% of male-, 81% of female- and 73% of youth-headed households did not have enough food to meet their needs in 2013, the year of study.

4.3 Climate-change and variability

The responses from both the FGDs and interviews for the three sub-locations reported increased incidences of crop and livestock losses due to droughts, increased temperatures, and erratic and unpredictable rainfalls, and drying up of rivers. There was declining agricultural production due to unpredictable, sometimes incessant rains on the one hand, as well as low rainfall, coupled with high temperatures on the other hand; the occurrence of extreme climatic events including hailstorms, frost, and persistent droughts. There was a clear indication of CC&V as seen from declining trend of rainfall and increasing trend of temperature, sun's heat, frequent droughts, and drying up of rivers (Figure 3 and Table 3). These conditions had worsened the food situation in the study sites. Figures 4–6, confirm that these trends were going to continue in a number of decades to come in the ASALs of Kenya. These weather patterns (Figures 4–6) were likely to deplete water and pasture resources, leading to natural resource scarcity; rising temperatures, changes in precipitation patterns and quantity, and incidence of storms and frosts (GoK, 2010). Figures 4–6, further, show that monthly total rainfall will continue decreasing at an increasing rate while mean maximum temperatures and the mean dry spell will continue increasing but at a decreasing rate. Loss of livestock and crops translated into food shortage and decrease in crop yields to the locals, hence their perception of increased hunger (Table 3). Respondents affirmed rainfalls were more regular and predictable in seasons 30 years ago when the seasons were distinct and good, but currently, rains have become more erratic and unpredictable hence the climate is 'bad', unlike three decades ago when climate was 'good', which respondents defined subjectively. This was consistent with climate data from the Kiboko/Makindu weather station showing increasing trend to droughts (Figure 2). Rainfall had reduced in both quantity and quality over the last three decades, negatively affecting conventional agriculture and necessitating CSA. The findings of this study concur with IISD (2010), which shows that drought events associated with CC&V have become more pronounced in Kenya in recent years. Besides, Ojwang et al. (2010), Njiru et al. (2009) and Conway (2009) all confirm that the eastern and northern ASALS in Kenya were witnessing an overall decrease in precipitation and an increase in temperatures due to CC&V. The negative impacts of CC&V were already evident in East Africa (Kipkoech et al., 2015). Changes in rainfall amount and patterns affect soil erosion rates and soil-moisture, both of which are significant for crop yields (Kotir, 2011).

4.4 Climate-smart agriculture innovations

Focus group discussions and interviewees identified a number of CSA agricultural technologies present in the watershed. The technologies included tied ridges, terraces/trenches, water harvesting, irrigation, CA, Zai pits, agro-forestry and mulching; soil fertility management technologies; crop management practices; improved varieties; livestock breeds; post-harvest and implements/machinery. However, a few smallholders had appreciable knowledge about CSA technologies on rhizobia inoculation and post-harvest technologies, yet post-harvest losses were high in the watershed (GoK, 2014). This notwithstanding, many smallholders in the watershed had some knowledge on soil and water, and soil fertility management technologies, some aspects of crop management, machinery and equipment issues. Although the adoption of these improved CSA technologies, was low, some smallholders were using CSA technologies such as; tied ridges, terraces/trenches, water harvesting, Zai pits, irrigation, mulching; animal manure/compost, agro-forestry, cover crops, crop rotation, intercropping, rhizobia inoculation; row planting, seed priming, and improved crop varieties in varied degrees where terraces/trenches were the highest and agro-forestry the least. The findings have shown that CSA was considered an opportunity for smallholders in the watershed to become more resilient to CC&V because it could offer them more security, stabilise their means of subsistence and lead to improved livelihoods (FAO, 2010). This concurs with case studies of Kipkoech et al. (2015) from Ethiopia, Kenya and Uganda, which show that CSA stands on various pillars, namely, CA, crop-diversification and cropland management, soil and water conservation/erosion control, more resilient food crops, risk insurance, fodder development, rangeland management, integration of livestock and crops, and integrated soil fertility management. However, from gender perspective, women and youths in Kalii watershed were particularly vulnerable to CC&V due to crop failures affecting food-security and other economic activities. Water scarcity, too, had become worse due to CC&V. Besides, CA interventions were not always gender-neutral in terms of labour requirements, empowerment, or economic benefits and costs, worsening the status of women and the youths as Nyanga et al. (2012) confirms that agricultural resources in HHs were strongly skewed towards men.

4.5 Decision-making

Generally, decision-making in Kalii on agricultural production, resources/assets, inputs, on-farm and off-farm incomes, sharing of proceeds and activities was controlled by both spouses. However, some decisions were dominated by one spouse than the other. Females made more decisions than men on most activities including crop produce, marketing, quantities sold, seed cleaning and purification, threshing, storage, milling, household equipment, household maintenance, and children's marriages. While men made more decisions than women on land issues, livestock, fertiliser use, farm equipment, credits, seeds, pesticides and children education. In crop production, decisions on food production was dominated by females with the exception of maize, regarded as a commercial crop. Decisions on cash crops and tree/fruit crops was by men in male-headed HHs (Figure 7). Decisions on key livestock assets was by men except those on disposal of poultry which were dominated by females. An interesting scenario was revealed regarding livestock during the FGDs. A wife who belonged to a Women Development Group could acquire a key livestock asset, a dairy cow/goat/sheep and bring it home. A husband would dispose such an asset without consulting the wife because as men believed, everything in the HH belonged to men, including the wife herself. On the contrary, a wife would always consult the husband before disposing that asset. The findings concur with that of Kristjanson in Njuki and Sanginga (2013) who showed that women in male-headed households were not involved in decision-making on disposal of key-livestock, their products and use of the proceeds. Besides, they were not adequately compensated, indicating a gender asset gap. The findings, too, concur with Bernier et al. (2015) on gender and institutional CSA practices in Kenya who found that though women performed most of the agricultural activities, they did not make major decisions on the sharing of proceeds from therein and were minimally compensated. Women, despite their associated management of income with important development outcomes, many women continued not to make decisions even on their own incomes (World Bank, 2012). The results also concur with Nyanga et al. (2012) on access to and control over land and other productive-assets, which mainly belonged to men. Sweetman (2012) explained, by closing the "gender gap" in access to resources, even without adding new resources to the HH economy, agricultural productivity increased significantly.

4.6 Multinomial logit regression results

The results of multinomial regression (Table 4) show that *ceteris paribus,* the odds of HH-size of a smallholder, selling its CSA produce to a group rather than to a seed-company were 2.8 times greater (increased 177%). The HH-size was significantly ($p = 0.006$) more likely to make them sell their produce to a group. The odds of the land-size and available labour a pulse smallholders used was 2.5 and 1.1 times greater (increased 145 and 147%) respectively thus making the smallholder sell their produce to a group rather than to a seed-company. This implied the smallholders, by selling their produce to groups, improved the markets for the produce due to collective-action. The land-size and available labour of the smallholder were significant ($p = 0.047$ and 0.014, respectively) and more likely made the smallholder choose selling one's produce to a group rather than to a seed-company. The odds of the age of a smallholder (*ceteris paribus*) made the smallholder choose to sell their produce to a broker rather than a seed-company, were 1.03 times greater (increased 3%). The results showed that the age of the HH head was significant ($p = 0.000$) in influencing the choice of a pulse smallholder to sell their produce to a broker rather than to a seed-company. This was because the older a smallholder became and under the CC&V, the less likely would travel a long distance to deliver his or her produce and would prefer a broker who collected it at farm-gate to maximise the profits received.

The odds of the education of a smallholder made them choose to sell their produce to a consumer rather than to a seed-company, were multiplied by 1.03 (increased 25%) and was significant ($p = 0.034$). An evidence that pulse smallholder's level of education was going to increase their understanding influencing their choice of selling produce to consumers rather than to a seed-company. The odds of the HH-size of a smallholder influenced their choice of selling produce to a consumer rather than a seed-company, were multiplied by 0.8 (decreased 24%) and was significant ($p = 0.000$). The odds of the land-size a smallholder cultivated influenced their choice of selling produce to a consumer rather than to a seed-company, were multiplied by 0.64 (decreased 36%) and was significant ($p = 0.012$). The odds of the distance to the market influenced a smallholder's decision to sell their produce to a consumer rather than to a seed-company, were multiplied by 0.17 (decreased 84%) and was significant ($p = 0.001$). The odds of the sources of information available and the decision-making were all significant under all the three buyers. Each of the categories was compared to an arbitrary reference category that was selected by the STATA programme used in the analysis. Relative risk ratios (rrr) were used to interpret the results. The chi-square (χ^2) test results were statistically significant (*p-value* 0.0001) at 0.05 confidence level and the null hypothesis (H_0: gender roles were not different from the gender-cadres involved in CSA at household level) was not rejected. The conclusion, there was an association between the gender roles and gender-cadres involved in the different CSA-related activities at HH level. The results of the Fisher's exact was *p-value* = 0.546 at 0.05 confidence level, and since there was no enough evidence for accepting the null hypothesis (H_0: innovations do not improve CSA in the Kalii watershed) the conclusion was innovative practices improved CSA in the Kalii watershed and there was an association between the gender-cadres involved in CSA activities. Fisher's exact test was used because the observed frequencies in some of the cells on the contingency table had a value of zero. These results concur with the findings of GoK (2014) on decision-making and sources of information in Makueni County and Bernier et al. (2015) on gender and institutional decision-making under CSA practices in Kenya.

4.7 Linear regression results

In the production of both improved cowpeas and green grams within the watershed (Tables 5 and 6), there were inefficiencies due to the under-utilisation and over-utilisation of the factors related to agricultural infrastructure and institutions as indicated by the coefficients. This is because the positive coefficients for farm size was 0.60 (cowpeas) and 0.19 (green grams); family size 0.17 (green grams); available family labour 0.19 (cowpeas) hired labour 0.14 (cow peas); use of improved seeds 0.28 (cowpeas); incomes from crop proceeds 0.49 (cow peas); source of information on CC&V 0.65 (cowpeas) and 0.48 (green grams); information on NRM 0.56 (cowpeas) and 0.37 (green grams); information on diseases 0.48 (cowpeas) and 0.29 (green grams); on storage 0.40 (cowpeas) and 0.23 (green grams) and collective action 0.61 (cowpeas) and 0.22 (green grams) had a direct relationship to the input-output analyses. The positive effect of farm size suggested a positive effect on the two crop outputs of cowpeas and green grams. An increase of 1% in the size of cowpeas and green gram croplands led to an increase in output of cowpeas by 0.61kg/ha and 0.19kg/ha of green grams respectively. The bigger the farm size, the higher the output realised that could be attributed to adopting of agricultural innovations. Ouma et al. (2006) suggested that the use of improved technologies would continue to be a critical input for improved farm productivity. Doss (2006), too, recognised that one way of improving agricultural productivity, in particular and rural livelihoods in general, was through the introduction and adoption of improved agricultural technologies to and by farmers. The available family and hired labour that were positive in cowpeas production showed that as the use of labour types increased so did the output of the cowpeas. The coefficients were all positively signed and statistically significant at either 1%, 5% or 10% respectively. This showed that they all had direct effect on cost allocation. The positive relationship of cost of farmland and cost allocation implied that an increase in cost of improved seeds and labour increased total cost of producing improved cowpeas and green grams in the study sites. Family size being positive in the case of green grams meant that an increase of 1% in the output of green grams led to 0.17kg/ha being consumed by the family. A 1% increase in use of improved cowpeas seeds meant that there was an increase of 0.28kg/ha to the cowpeas output. The coefficient on CC&V (0.65) demonstrates that the smallholders in the watershed were keen and well informed on the challenges of climate and variability.

The results of the marginal analyses (Tables 7 and 8), characterised smallholders with the increasing (+) or decreasing (–) extent of the improved cowpeas and green gram being marketed within the watershed. The coefficients of the determinants showed that smallholders were different based on the extent of marketing of the two commodities. The results represented positive and negative influence on the marketing of the two commodities as anticipated based on economic theory. This was because in some cases it was found that more produce was sold than what was actually produced. The results concur with the findings of GoK (2014), which also found that small quantities were produced and yet more was sold by some of the households in the county. This could be attributed to the fact that some of the smallholders also acted as business persons and bought more produce from other smallholders that they in turn sold. Normally, the larger the area under a crop, the higher was the yield and incomes generated depending on the prevailing commodity market unit price. Low percentages of smallholders in the watershed growing the green grams were the reason for the decreasing magnitude of the marketed green grams amount. A similar assumption to the large physical area under the crop in relation to the marketing of the crops was on the family size. Large families consumed greater portion of the produce than small ones, consequently reducing the amount for sale. However, the results in this study showed increasing magnitude of the marketing of cowpeas in the watershed due to the family size and this could have been due to the labour being supplied. The values of the adjusted R-squared (R^2) of 0.948 and 0.959 for cowpeas and green grams respectively implied that 95 and 96% of the regression equations were a good fit of the target sample data.

5 Conclusions and recommendations

This paper endeavoured to depict the understanding of gender, agricultural innovations, CC&V, and CSA in the setting of local perceptions, historical climate data, coping and adaptation strategies from the viewpoint of Kalii watershed smallholders. On the basis of FGDs and interviews, the different gender cadres in the watershed had their visions. Men dreamt of a food, income secure and educated community with improved livelihoods. Women wanted good water (an important resource) conservation for increased agricultural production, food-security, incomes and higher livelihoods. The youths wanted their parents to give them land and other resources for them to engage in agricultural production for livelihoods. The county administrators wanted self-reliance in food-security, green environment, less domestic problems, sales to improve peoples' livelihoods and health. Most HHs accessed water from the Kiboko River and its tributaries, and boreholes though sometimes the river water was insufficient and of poor quality. Most HHs received their farming knowledge from other smallholders, indigenous technical knowledge, extension staff, researchers and non-governmental organisations. Although some HHs had adopted some CSA technologies, adoption was still low due to the cost involved and some technologies being labour-intensive. However, those who used some CSA technologies believed that the technologies gave them good livelihood benefits. Women performed most of the activities and made many decisions on most agricultural activities including crop produce, marketing, quantity sold, seed cleaning and purification, threshing, storage and milling. There was enough evidence that Kalii watershed had witnessed CC&V. Smallholders perceived their microclimate variations and were able to cope and adapt accordingly.

There was need for the smallholders to fully adopt CSA if they have to achieve food and nutrition security and improved livelihoods. The county government, its agencies and key development partners working in the county and particularly within the Kalii watershed should educate the smallholders on the benefits of adopting CSA, gender-responsive technologies and put in place new strategies required to increase smallholders' adoption of resilient farming systems, which have the flexibility to deal with stresses and disturbances as a result of CC&V. The policy and law must consider the youth when planning and executing CC&V related policies because the youth represent a cross-over between the present and future generations, and play a critical role in socio-economic development. The CC legislation and amendments to sectoral laws must carve out specific roles and opportunities for either gender to participate in decision-making in CC governance and pursue opportunities that arise through CC&V actions (Wambugu, 2014). However, to achieve this, integration of local knowledge into climate policies is likely to increase legitimacy of the decision-making process of the smallholders. This demands that adaptation interventions' search for solutions should involve the smallholders rather than prescribing solutions, which smallholders may not view as feasible or attractive. This will make smallholders own the process and give a feedback on what was shared with them on the findings of the study. Invariably, gender and innovations are very critical in CSA for food and nutrition security under the ever changing CC&V.

References

Asenso-Okyere, K., Davis, K and Aredo, D. (2008) *Advancing agriculture in developing countries through knowledge and innovation: Synopsis of an international conference*, International Food Policy Research Institute, Washington, DC.

Awuor, C. (2009) 'Increasing drought in Kenya', in Ensor, J. and Berger, R. (Eds): *Understanding Climate Change Adaptation: Lessons from Community-based Approaches*, Practical Action, UK, pp.101–114.

Bernier, Q., Meinzen-Dick, R., Kristjanson, P., Haglund, E., Kovarik, C., Bryan, E., Ringler, C. and Silvestri, S. (2015) *Gender and Institutional Aspects of Climate-Smart Agricultural Practices: Evidence from Kenya*, CCAFS Working Paper No. 79, CGIAR Research Program on Climate-Change, Agriculture and Food-security (CCAFS), Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org (accessed on 16 February 2016).

Beuchelt, T.D. and Badstue, L. (2013) 'Gender, nutrition- and climate-smart food production: opportunities and trade-offs', *Food Security*, Vol. 5, No. 5, pp.709–721.

Boto, I., Biasca, R. and Brasesco, F. (2012) *Climate-Change, Agriculture and Food-Security: Proven Approaches and New Investments*, Brussels Rural Development Briefings, Briefing no. 29, 27 September.

Conway, G. (2009) *The Science of Climate-change in Africa: Impacts and Adaptation*, Department for International Development (DFID), London, UK, p.24.

Davis, K., Ekboir, J. and Spielman, D. (2008) 'Strengthening agricultural education and training in sub-Saharan Africa from an innovation systems perspective: a case study of Mozambique', *The Journal of Agricultural Education and Extension*, Vol. 14, No. 1, pp.35–51.

Doss, C.R. (2006) *Understanding Farm Level Technology Adoption: Lessons learnt from CIMMYT's Micro-survey in Eastern Africa*, CYMMIT Economic Working, Mexico, D.F., pp.7–30.

FANRPAN (Food, Agriculture and Natural Resources Policy Analysis Network) (2013) *Climate Smart Agriculture Initiatives*, Royal Swazi Sun International, Swaziland, 13 March.

FANRPAN (2012) *Climate Smart Agriculture: More Than Technologies Are Needed to Move Smallholder Smallholders toward Resilient and Sustainable Livelihoods*, Policy Brief, No. 2, Volume XIII, June. Available online at: http://www.fanrpan.org/themes/ resources/ (accessed on 16 February 2016).

FAO (2014) *Science to Support Climate-Smart Agricultural Development: Concepts and Results from the MICCA Pilot Projects in East Africa*, Mitigation of Climate-change in Agriculture, Series 10, Rome.

FAO (2010) *Climate-smart Agriculture: Policies, Practices, and Financing for Food-security, Adaptation, and Mitigation*, FAO, Rome.

FARA (2015) *Barriers to scaling up/out climate smart agriculture and strategies to enhance adoption in Africa*, Forum for Agricultural Research in Africa, Accra, Ghana.

GoK (Government of Kenya) (2007) *Kenya Vision 2030*, Ministry of State for Planning National Development and Vision 2030, Kenya Government Printers, Nairobi.

GoK (2010) *National Climate-change Response Strategy*, Ministry of Environment and Mineral Resources, Kenya Government Printers.

GoK (2014) *Agricultural Sector Development Support Programme (ASDSP) Makueni County HH Report*, Ministry of Agriculture, Livestock and Fisheries, Nairobi, Kenya.

Hoffmann, J. (2003) *Generalized Linear Models: An Applied Approach*, Allyn & Bacon, Boston, MA.

Ifejika-Sperenza, C. (2010) *Resilient Adaptation to Climate-change in African Agriculture*, German Development Institute, University of Bern, Centre for Development and Environment.

IISD (International Institute for Sustainable Development) (2010) *Enhancing resiliency to drought in Kenya's arid and semi-arid lands*, Canadian Coalition on Climate-change & Development. Available online at: http://www.iisd.org/climate/vulnerability/adaptation.asp (accessed on 16 February 2016).

IPCC (2007) *Impacts, Adaptation and Vulnerability*, Summary of the Policymakers. Contribution of Working Group II to the Fourth Assessment Report of the IPCC (Intergovernmental Panel on Climate-change), Cambridge University Press, UK.

Kakooza, J.K. (2005) *Gender Variation in Agricultural Technology: A Comparative Analysis of Two Ecological Zones of Uganda*, A Report for ASARECA and ECAPAPA, August.

Kipkoech, A.K., Tambi, E. and Bangali, S. (FARA) (2015) *State of Knowledge on CSA in Africa, Case Studies from Ethiopia, Kenya and Uganda*, Forum for Agricultural Research in Africa, Accra, Ghana, ISBN 978-9988-8514-3-5.

Klerkx, L., van Mierlo, B. and Leeuwis, C. (2012) 'Evolution of systems approaches to agricultural innovation: concepts, analysis and interventions', *Farming Systems Research into the 21st Century: The New Dynamic*, Springer, pp.457–483.

Klerkx, L., Hall, A. and Leeuwis, C. (2009) 'Strengthening agricultural innovation capacity: are innovation brokers the answer?' *International Journal of Agricultural Resources, Governance, and Ecology*, Vol. 8, Nos. 5/6, pp.409–438.

Kotir, J.H. (2011) 'Climate-change and variability in sub-Saharan Africa: a review of current and future trends and impacts on agriculture and food-security', *Environ. Dev. Sustain.*, Vol. 13, pp.587–605.

Kumar, N. and Quisumbing, A. (2012) *Women's groups versus HHs: Approaches to achieve food-security and gender equality*, Food-security Insights: Research findings for development policymakers and practitioners, Institute of Development Studies, University of Sussex.

Lambrou, Y. and Nelson, S. (2010) *Smallholders in a Changing Climate: Does Gender matter?* FAO, Rome, Italy.

Leeuwis, C. and Aarts, N. (2011) 'Rethinking communication in innovation processes: creating space for change in complex systems', *Journal of Agricultural Education and Extension*, Vol. 17, No. 1, pp.21–36.

Lobell, D.B., Schlenker, W. and Costa-Roberts, J. (2011) 'Climate trends and global crop production since 1980', *Science*, No. 333, pp.616–620.

Lynn, P. (2009) *Sample Design for Understanding Society*, Understanding Society Working Paper 2009-01, University of Essex, Colchester.

Meinzen-Dick, R., Bernier, Q. and Haglund, E. (2013) *The six "ins" of climate-smart agriculture: Inclusive institutions for information, innovation, investment, and insurance*, CAPRi Working Paper No. 114, International Food Policy Research Institute, Washington, DC. Available online at: http://dx.doi.org/10.2499/CAPRiWP114 (accessed on 16 February 2016).

Milder, J., Majanen, T. and Scherr, S. (2011) *Performance and Potential of Conservation Agriculture for Climate-change Adaptation and Mitigation in Sub-Saharan Africa: An Assessment of WWF and CARE Projects in Support of the WWF-CARE Alliance's Rural Futures Initiative*, Final Report, EcoAgriculture Partners and CARE-WWF Alliance.

MoDP (Ministry of Devolution and Planning) (2015) *National Policy for the Sustainable Development of Northern Kenya and other Arid Lands 'Unlocking Our Full Potential for Realization of the Kenya Vision 2030*, Ministry of Devolution and Planning, Government Printers, Nairobi, Kenya.

MoDP (2013) *County Development Profile (CDP) for Makueni*, Ministry of Devolution and Planning, Government Printers, Nairobi, Kenya.

Ngugi, R.K. and Nyariki, D.M. (2005) 'Rural livelihoods in the arid and semi-arid environments of Kenya: sustainable alternatives and challenges', *Agriculture and Human Values*, Vol. 22, No. 1, pp.65–71.

Njiru, E.N. (2009) *Assessing the impact of climate variability and change on maize performance in semi-arid eastern Kenya*, Unpublished MSc Thesis, Department of Land Resource Management and Agricultural Technology (LARMAT), University of Nairobi, Kenya.

Njuki, J. and Sanginga, P.C. (Eds) (2013) *Women, Livestock Ownership and Markets: Bridging the Gender Gap in Eastern and Southern Africa*, Routledge, London, UK.

Nyanga, P., Johnsen, F.H. and Kalinda, T.H. (2012) 'Gendered impacts of conservation agriculture and paradox of herbicide use among smallholder farmers', *International Journal of Technology and Development Studies*, Vol. 3, No. 1, pp.1–24.

Ojwang, G.O., Agatsiva, J. and Situma, C. (2010) *Analysis of Climate-change and Variability Risks in the Smallholder Sector: Case studies of the Laikipia and Narok Districts representing major agro-ecological zones in Kenya*, FAO, Rome, Italy.

Ouma, J.O., De Groote, H. and Owuor, G. (2006) 'Determinants of improved maize seed and fertilizer use in Kenya: policy implication', *Presented at the International Association of Agricultural Economists' Conference*, Gold Coast, Australia, August, pp.12–18.

Schwab, J.A. (2002) *Multinomial logistic regression: Basic relationships and complete problems*. Available online at: http://www.utexas.edu/courses/schwab/sw388r7/SolvingProblems/ (accessed on 16 February 2017).

Spielman, D.J., Davis, K., Negash, M. and Ayele, G. (2010) 'Rural innovation systems and networks: findings from a study of Ethiopian smallholders', *Agriculture and Human Values*, Vol. 28, No. 2, pp.195–212.

Sweetman, C. (2012) *Innovative approaches to gender and food-security: Changing attitudes, changing behaviours. Food-security Insights: Research findings for development policymakers and practitioners*, Brighton, Institute of Development Studies, University of Sussex, p.82.

Tadesse, D. (2010) *The Impact of Climate-change in Africa*, ISS Paper No. 220, Institute for Security Studies, Pretoria, S.A.

Vittinghoff, E., Shiboski, S.C., Glidden, D.V. and McCulloch, C.E. (2005) *Regression Methods in Biostatistics: Linear, Logistic, Survival, and Repeated Measures Models*, Springer Science + Business Media, Inc., New York.

Wambugu, S.K. (2014) *A Comprehensive Scoping and Assessment Study of Climate Smart Agriculture (CSA) Policies in Kenya*, FANRPAN (Food, Agriculture and Natural Resources Policy Analysis Network).

World Bank (2012) *World Development Report 2012*, Gender Equality and Development, Washington, DC.

Ziervogel, G., Nyong, A., Osman, B., Conde, C., Cortés, S. and Downing, T. (2006) 'Climate variability and change: implications for household food-security', *Assessment of Impacts and Adaptations to Climate-change (AIACC)*, Washington, DC, USA.