INDICATORS OF RELATIVE SUSTAINABILITY IN SMALLHOLDER POTATO FARMING IN KENYA

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ABSTRACT

A key challenge facing the growth of agricultural sector in Kenya is the achievement of sustainable agriculture in the face of climate change. The impact of climate change has triggered smallholder farmers to resort to numerous adaptation strategies; collectively referred to as Climate Smart Agricultural Practices (CSAPs). Despite the continued use of CSAPs, climate change continues to threaten sustainability of potato farming. Partly, this is due to challenges in methodologies used in sustainability evaluations. One of the most important steps in policy interventions that are geared towards enhancement of relative sustainability of smallholder potato farming is the development of smart indicators. This study sought to develop smart indicators for relative sustainability in CSAPs related evaluation. This study adopted a qualitative research design. A total of 12 key informant interviews and four focus group discussions (each comprising of 10 members) were conducted. Data was organized and analyzed using NVivo (version 12) software. The study results revealed that four sub indicators are key in developing a composite indicator for relative sustainability in the assessment of contribution of CSAPs in smallholder potato farming. These included economic sustainability, enterprise sustainability, social sustainability and environmental sustainability. The main components of the four sub indicators are as follows: economic sustainability (farm productivity, profitability and economic stability); enterprise sustainability (farm management); social sustainability (social and institutional factors); and, environmental sustainability (use of organic fertilizers, use of agrochemicals, practice of crop rotations, practice of organic farming, practice of conservation agriculture and resource conservation technologies, practice of cover cropping and, use of certified seeds). This study recommends that evaluation research on farming sustainability should at least include four sub indicators of relative sustainability (economic sustainability, enterprise sustainability, social sustainability and environmental sustainability).

Keywords: Smart indicators, relative sustainability, evaluation, Climate Smart Agricultural Practices (CSAPs), potato farming

INTRODUCTION

A key challenge facing agricultural sector in Kenya as well as most other developing countries in their bid to achieve sustainability is how to deal with the reality of climate change (Gilbert, 2015). Some of the key climate related shocks include rise in air temperatures over land, rise in air temperatures over oceans, decrease in arctic sea ice and melting of glaciers, rise in sea levels, increase in humidity, increase in ocean heat content, increase in sea surface temperature, decrease in snow, and increase in earth's lower atmosphere temperature (IPCC, 2012). Rise in air temperatures over land leads to increase in the frequency and severity of droughts and heat waves, destructive wildfires, failed crops and low water supplies. Rise in air temperatures over oceans leads to more floods, more hurricanes and more extreme precipitation events. Decrease in arctic sea ice and melting of glaciers leads to rise in global temperatures. Rise in sea levels leads to intensified storms, more extreme flooding occurrence and threat for marine life. Increase in humidity leads to greenhouse effect and more energy use. Increase in ocean heat content leads to higher sea levels, melting glaciers, and stress to marine ecosystems. Increase in sea surface temperature leads to stronger and more frequent storms. Decrease in snow leads to higher absorption of sun's energy by earth. Increase in earth's lower atmosphere temperature leads to greenhouse effect (IPCC, 2014).

In their goal to reduce their vulnerability to the harmful effects of climate change, smallholder farmers have resorted into numerous adaptation strategies, popularly known as Climate Smart Agricultural Technologies and

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Management Practices (CSA TMPs) (CCAFS, 2020). One of the main goal behind emergence of CSA TMPs is to enhance sustainability of agricultural systems in the light of climate change (Kinyangi *et al*., 2015). CSA TMPs include adaptations relating, but not limited to, agronomic practices; prudent choice of seed varieties; integrated soil, water, and nutrient management; integrated pest and disease control and management.

Potato (*Solanum tuberosum*), the second most important food crop in Kenya after maize, is a major source of carbohydrates and therefore of high nutritional value. It also matures in 3 to 4 months only with a productivity that is five times higher than maize that takes 3 to 8 months depending on variety. Potato is a major contributor towards Kenya's national goal for food and nutrition security, poverty alleviation, job creation and industrial products (CIP, 2019). According to World Bank (2019), potato can efficiently address food insecurity and alleviate poverty in Kenya. About 3 million metric tonnes (MT) of Irish potatoes were produced from about 160,000 hectares (ha), generating over 50 Billion Kenya shillings (KES) in year 2019 (Potatopro, 2020).

Sustainability of most food crops has been deteriorating. Lack of social, economic, and environmental sustainability in agricultural activities is predicted to impact negatively on food security and livelihoods in the near future. As a result of increase in population, food systems are faced with the responsibility of meeting the growing food demands, even amidst the negative impact of climate change. Globally, it is estimated that food production must increase by at least 70 percent in the next 50 years in order to supply enough food to the world growing population. Achieving such productivity growth without exacerbating environmental problems in already fragile farming systems remains a major concern (Tilman *et al*., 2011). CSA TMPs promises a possibility of increasing productivity (CCAFS (2020). Climate change has been attributed to increased agricultural intensification, which by extension, has been associated with adverse environmental and social effects (Li *et al*., 2013). Kuhlman and Farrington (2010) recommended that sustainability should encompass three important pillars, namely economic, social and environmental dimensions. These pillars of sustainability are also considered as key dimension when exploring agricultural productivity. The ability to measure and monitor farm sustainability constitutes an important step towards designing policies and interventions for encouraging sustainability of production systems. However, sustainability assessments are limited by difficulties in identifying common indicators and to apply these indicators to create indices. The multi-dimensional nature of sustainability makes it difficult to both operationalize and to develop appropriate indicators (Dantsis *et al*., 2010; Hayati *et al*., 2010). Developing appropriate indices is also compounded by embedded social values, conflicting goals and multiple interactions between sustainability dimensions, as well as general heterogeneity in societal preferences (Robinson *et al*., 2015). The complexity and uniqueness of farming systems implies that sustainability indicators can be meaningful in one system, but irrelevant in another (Speelman *et al*., 2007). Therefore, it is often appropriate to use local farming, system-specific indicators for sustainability assessment. Sustainability assessments typically involve combining several indicator variables (Dong *et al*., 2015). Composite indices help in comparison of relative sustainability between farms (Gómez-Limón and Sanchez-Fernandez, 2010). According to Dantsis *et al*. (2010), Hayati *et al*. (2010), Mutyasira (2017), Reig-Martínez *et al*. (2011), Speelman *et al*. (2007) and Vitunskiene and Dabkiene (2016), sustainability indices in smallholder farming should include key dimensions such as economic sustainability, enterprise sustainability, social sustainability and environmental sustainability. Many evaluators use data-based methods such as Data Envelopment Analysis (DEA), Principal Component Analysis (PCA) and Factor Analysis (FA) to add more structure to the way weights are assigned in composite indices (Dong *et al*., 2015).

Despite the continued use of CSAPs, climate change continues to threaten sustainability of potato farming. Partly, this is due to challenges in methodologies used in sustainability evaluations. One of the most important steps in policy interventions that are geared towards enhancement of relative sustainability of smallholder potato farming is the development of smart indicators. This study sought to develop smart indicators for relative sustainability in CSAPs related evaluation.

MATERIAL AND METHODS

Study area

The study was carried out in Taita-Taveta, Nyandarua, Nyeri and Elgeyo Marakwet Counties in Kenya. The four counties correspond with the main Agro Ecological Zones

(Zone II and III) where majority of potato farming is done in Kenya. Purposive sampling was used to sample the key interviews. Sampling was done in each of the target population in the four Counties.

Data Collection and management

This study used qualitative research design. This design made it possible to identify a set of indicators for relative farm sustainability in smallholder potato farming in Kenya. Key Informants Interviews (KIIs) and Focus Group Discussions (FGDs) were conducted in order to gather data. A total of 12 KIIs and four FGDs (each comprising of 10 members) were conducted. The KIIs and FGDs were used to collect primary data on important factors that were considered as suitable indicators of relative sustainability in smallholder potato farming in specific counties. Qualitative data from FGDs and KIIs (transcripts) were analyzed using the Nvivo software (Version 12) and interpreted using a thematic approach. The audio recorded interviews and notes were transcribed in Microsoft word. Each transcript was given a unique identifier that comprised the location, date, and participant identifier, allowing enhanced confidentiality and anonymity. Subsequently, the data was coded into themes emerging from the data for content analysis. Following Speelman *et al*. (2007), Dantsis *et al*. (2010), Reig-Martínez *et al*. (2011), Vitunskiene and Dabkiene (2016) and Mutyasira (2017), , and, a catalogue of key variables that can act as indicators of sustainability was developed. These indicators related to dimensions such as economic sustainability, enterprise sustainability, social sustainability and environmental sustainability.

RESULTS AND DISCUSSIONS

A catalogue of key variables that can act as indicators of sustainability was developed by the researcher. This list was further expanded following 12 key informant interviews and four focus group discussions during when classification into various dimensions of sustainability was done. Based on their relevance to smallholder farming, computational/data collection ease and policy implication, the most appropriate indicators were shortlisted. The final list of variables (both qualitative and quantitative) is presented in Table I.

The study results revealed that four sub indicators are key in developing a composite indicator for relative sustainability of smallholder potato farming in Kenya for use in research on contribution of climate smart agricultural technologies and management practices in smallholder potato farming in Kenya. These were: 1) economic sustainability, 2) enterprise sustainability, 3) social sustainability and 4) environmental sustainability. The most important components of economic sustainability were found to be factors relating to farm productivity and profitability.

Indicators of economic sustainability of smallholder potato farming were further classified into three: farm productivity, farm profitability and economic stability. Farm productivity indicators included labour productivity and capital productivity. Household profitability (income) indicators included farm income and non-farm income.
The most important indicators of economic stability were found to be factors relating to risk exposure. They included enterprise diversification index (extent of engagement on both crop and livestock farming), crop diversification index (number of crops grown) and livelihood diversification index (extent of engagement in both on-farm and off-farm activities).

Indicators of enterprise sustainability of smallholder potato farming included factors relating to farm planning (availability of business plan) and farm management (presence of financial management and record keeping measures/functions).

The most important components of social sustainability were found to be factors relating to social and institutional factors. Important social factors included household wealth, household size and household workforce (total members of the household that can provide family labour, i.e. 18 – 50 years old). Important institutional factors with dimension of social sustainability included membership in farmer organizations, access to agricultural credit, access to extension services and distance to input/output market.
The most important components of environmental sustainability of smallholder potato farming included factors relating to access and use of climate smart agricultural technologies and management practices such as use of organic fertilizers/manure, use of inorganic agrochemicals, practice of crop rotations, practice of organic farming, practice of conservation agriculture/ resource conservation technologies (RCTs), practice of cover cropping and use of certified seeds.

TABLE I- INDICATORS FOR ASSESSING THE SUSTAINABILITY OF SMALLHOLDER POTATO FARMING

Dimension	**Sub-dimension**	**Indicator**	**Description**	**Type**
Economic sustainability	Farm productivity	Labour productivity	Farm gross value added per labour input (KES /man-day).	+
		Capital productivity	Ratio of gross value added to capital inputs (KES).	+
	Farm profitability	Farm income	Total income from crop and livestock enterprises (KES per annum /acre).	+
		Non/off-farm income	Total income from off- and non-farm sources (KES per annum).	+
	Economic stability	Enterprise diversification	Farmer engagement in both crop and livestock farming (Yes/No)	+
		Crop diversification	Growing of multiple crops in the same farm (Yes/No)	+
		Livelihood diversification	Engagement in off-farm activities (Yes/No)	+
Enterprise sustainability	Farm planning	Farm business plan	Whether the farmer have a farm business plan (Yes/No)	+
	Farm management	Financial management measures	Whether the farmer has implemented measures on financial management (Yes/No)	+
		Record-keeping	Whether the farmer practice record-keeping (Yes/No)	+
Social sustainability	Social factors	Socio-economic status	Farmers' rating of their socio-economic status (high, medium, low)	+
		Household size	Total number of members in the household	+
		Family labour size	Number of household members who provide family labour (18-50 years)	+
	Institutional factors	Group Membership	Membership to a farmer organization (Yes/No)	+
		Agricultural credit	Household access to agricultural credit (last 1 year) (Yes/No)	+
		Extension services	Household access to extension services (last 1 year) (Yes/No)	+
		Input market distance	Household distance to input market (km)	-
		Output market distance	Household distance to output market (km)	-
Environmental sustainability	Climate smart agricultural technologies and management practices	Organic farming	Does the farmer practice organic farming? (Yes/No)	+
		Conservation Agriculture (CA)	Does the farmer practice conservation agriculture? (Yes/No)	+
		Cover cropping	Does the farmer practice cover cropping? (Yes/No)	+
		Crop varieties	Does the farmer grow CSA crop varieties? (Yes/No)	+
		Soil management practices	Has the farmer implemented soil management CSA TMPs? (Yes/No)	+
		Water management practices	Has the farmer implemented water management CSA TMPs? (Yes/No)	+
		Nutrient management practices	Has the farmer implemented nutrient management CSA TMPs? (Yes/No)	+
		Pest management practices	Has the farmer implemented pest management CSA TMPs? (Yes/No)	+
		Disease management practices	Has the farmer implemented disease management CSA TMPs? (Yes/No)	+

Note: Indicator type: '+' means more is better and '–' means less is better

The findings of this study agree with Kuhlman and Farrington (2010) and Kates *et al*. (2005) who in their separate studies found that farming sustainability should encompass three important pillars, namely economic, social and environmental dimensions. The concept of maintaining all pillars is an important dimension when assessing the contribution of agricultural technologies and management practices on relative sustainability. The results from this study also concurs with Dantsis *et al*. (2010), Hayati *et al*. (2010), Mutyasira (2017), Reig-Martínez *et al*. (2011), Speelman et al. (2007) and Vitunskiene and Dabkiene (2016) who recommended that suitable indicators for sustainability assessments should involve many indicator variables across economic, social and environmental sustainability dimensions.

CONCLUSIONS AND RECOMMENDATIONS

For sound assessment of contribution of CSAPs in smallholder potato farming, four sub indicators are important in developing a composite indicator for relative sustainability. These included economic sustainability, enterprise sustainability, social sustainability and environmental sustainability. The main components of the four sub indicators are as follows: under economic sustainability (i) farm productivity, (ii) profitability and (iii) economic stability; under enterprise sustainability - farm planning and management; under social sustainability - social and institutional factors; and under environmental sustainability - use of climate smart agricultural technologies and management practices. This study recommends that evaluation research on farming sustainability should at include four sub indicators of relative sustainability (economic sustainability, enterprise sustainability, social sustainability and environmental sustainability).

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