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Gendered Impact Assessment on Food Securing Upgrading Strategies: Results from Three Methodological Approaches

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Abstract
In developing countries, rural women and men play different roles in guaranteeing food security for their households and communities. The gendered aspects of food security are visible along the four pillars of food security: availability, access, utilization and stability but one cause reported to hamper ineffectiveness is overlooking gender dynamics. Therefore this study aims to explore the gendered arguments towards food security by using different methodological tools while focusing on the food security criteria and the three sustainable development criteria (economic, social and environmental aspects). The specific objectives were to analyse differences between scientist and farmer perspectives in relation to the three upgrading strategies namely rainwater harvesting (RWH), improved processing, and household nutrition education and kitchen gardening) and to find out the difference in results when triangulating the tools on target group in order to set preferences in local contexts which helps to anticipate what measures would be needed to improve food security. The study used diverse assessment approaches namely a) a participatory stakeholder approach using the FoPIA tool (Framework for Participatory Impact Assessment) b) a scientific expert based approach using ScalA-FS (scaling up assessment-Food security tool), and c). Gender Analysis Matrix (GAM). Focus group discussions, key informant interviews and household survey were the main methods of data collection. The study found that female and male participants scored the criteria differently. Men considered social *relations in the community* and *in the household* more important for food security than women did. Women scored several production-related aspects as more important than men. Gender-based inequalities along the food value chain 'from farm to plate' that impede the attainment of food and nutritional security must therefore be addressed through effective gender responsive policies and programs.
Keywords: impact assessment; gender; upgrading strategies; food value chain; Tanzania; participatory research

1.0 Introduction
1.1 Background
Agriculture can be the engine of growth and is necessary for reducing poverty and food insecurity, particularly in sub-Saharan Africa (IFAD 2001; World Bank 2007a). Therefore, understanding the dynamics of change is crucial to better position the sector for faster growth and sustained development, which is vital for food and livelihoods security. Generally, many of the development inequalities emerge from gender differences. These differences in particular affect the distribution of resources between men and women, and are caused by ideological, economic, ethnic, social and religious factors. Hence gender's consideration as a determinant that influences development results, particularly in relation to poverty reduction and food security (Frison *et al.,* 2011).

In Tanzania, food insecurity is one of the focal national issues. The Tanzanian government has adopted the Agricultural Sector Development Programme (ASDP) and the current agricultural development initiative Kilimo Kwanza (Agriculture first).These programmes address the challenges such as food insecurity, the patriarchal system, the customs, and the traditions that discriminate against women and perpetuate gender inequalities (URT, 2015). In Tanzania, despite constitutional proclamations of gender equality and many laws that promote equal opportunities for both men and women it remains that for both smallholder farms and large plantations, men and women carry out different types of work, have different preferences and are unequally rewarded for their contributions to the agricultural system (Rubin, 2010).

The international community currently lacks consensus about the criteria that are needed to properly evaluate food security at the household level (Carletto et al., 2013). Several authors argue that a fixed set of criteria would be inappropriate to describe unique and complex systems and that food security criteria must be locally specific and relevant *(López-Ridaura et al., 2005; Agol et al.,* 2014; Bell and Morse 2008; Cosyns et al., 2013).

Little effort has been directed towards the development of methodological approaches to support the selection of site-specific criteria (López-Ridaura et al.*, 2005)* in the agricultural development context, and simple, applicable field approaches that actively involve local farmers are lacking in particular. Such participatory approaches have higher potential for enhancing sustainable agriculture and food security (Chambers 1995; Neef and Neubert 2011). Only context-related criteria can be useful for systematic impact assessment, monitoring and evaluation of development measures to improve food security.

The relationship between gender and food security is undeniable and of utmost importance (Gaanderse, 2010). The concept of food security includes both physical and economic access to address people's needs and preferences. In that way, a household should have the possibility to consider all its members at all times. The three main pillars towards ensuring food security are food availability, food access, and food utilization (FAO, 2013). According to Coles and Mitchell (2011) upgrading strategies are the interventions to improve efficiency and equity by maximising the benefits received by its participants (and may be typified as process and product upgrading, functional upgrading and chain upgrading).

The study on which this paper is based adopted the process and product upgrading (process and product upgrading (Bassett, 2009). Theoretically, in Sub-Saharan, women generally have the right to dispose of the product and income from their own economic activities (Dey, 1992). For example; Dolan (2001) reported how traditional household income distribution arrangements in Meru District, Kenya permitted women to retain money from the sale of local food crops to spend on household subsistence needs. However, male appropriation of the new French bean income, sometimes through violence toward their wives, has resulted in a situation where women perform 72 percent of labour and enjoying only 38 percent of the income. Therefore, it is important to examine what food security criteria in the UPS will be advantageous to women and men in achieving food security. The objective of this paper is to examine the gender-differentiated impacts of food securing UPS. Specifically, the paper explores quantitative and qualitative data in endeavor of getting a better understanding of the food security problem and examines processes/experiences along with the impact assessment outcomes of gender issues (Clark, 2010).

1.2 Gender in the Context of Food Securing Upgrading Strategies

The majority of Tanzanian farmers are women who constitute the majority of agricultural labour force. Over 90.4 per cent of active women in Tanzania are engaged in agricultural activities, producing about 70 percent of the country food crop requirements. They are also actively involved in the production of cash crops and in household activities. Most of these jobs involve strenuous, manual and highly time consuming undertakings (NAP, 2013: URT, 2013).

Research shows that from 2000 to 2013 the concept of food security includes political, economic and social characteristics (Farnworth *et al.,* 2016). Although food security has the same impacts on people in both developing and developed countries, different social and political factors influence the availability, stability, utilization and access to food (Hadley and Crooks 2012; FAO 2006). Generally, a good understanding of gender issues in the context of the four food security pillars is extremely important. However, many researchers consider gender to be a complex (and/or delicate) topic (Touzard and Templez, 2012). For this reason, nutrition and food security specialists frequently spend limited time addressing gender dimensions, even though gender-sensitive actions are effective and empowering ways to tackle food insecurity (Farnworth *et al.,* 2016). While addressing food security or gender singularly can improve nutrition and livelihoods, a holistic approach can accelerate progress (Quisumbing *et al*., 2014).

Nonetheless, various interpretations of gender exist; there is a common understanding that women and men should have equal rights and opportunities. Women continue to face discrimination and often have less access to power and resources, including those related to food and nutrition security .Moreover, the roles, priorities, needs and use of resources do differ between men and women, and the way women and men are affected by food insecurity actions does also differ (Fischer and Qaim, 2012). The tendency is to focus on women when addressing gender, yet this overlooks the instrumental role of men in closing the gender gap. Therefore, both men and women need to be involved in this process, acknowledging their respective roles and needs, and fostering mutual awareness and partnership (Quisumbing *et al.,* 2014). Improving food security requires behaviour change of individuals within the household members that are responsible for food selection, preparation, and storage and allocation tasks. While women play a major role in food decisions in many cultures, it is increasingly recognized that research needs to target both women and men with utilization messaging given the role that men often play in influencing women's decision-making (Tsikata and Yaro; 2014 and Farnworth *et al*., 2016).

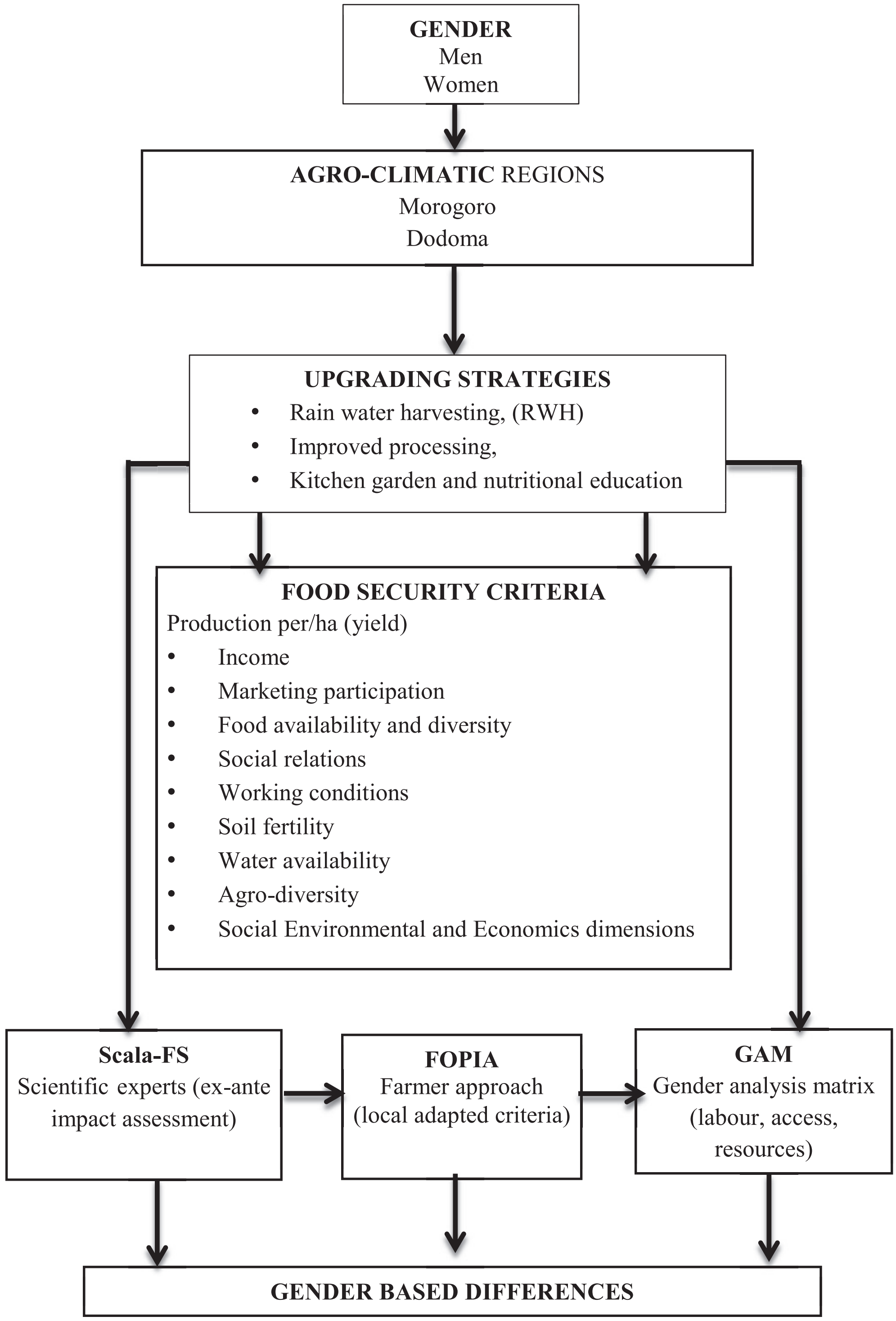

Figure 1: Gender Assessment conceptual framework

2.0 Research Methodology

2.1 Study Area and Food Systems

Description of the study areas

Approximately 90 per cent of Tanzania's poor people live in rural areas. The incidence of poverty varies greatly across the country but is highest among rural families who live in arid and semi-arid regions and depend exclusively on livestock and food crop production (URT,2014).The smallholder agricultural sector provides 95%

of the national food requirements while approximately 83% of individuals live below the basic needs poverty line, which is defined as the costs of meeting the minimum adult calorific requirement with a food consumption pattern typical of the poorest 50 % of the Tanzanian population, inflated by the non-food share of expenditure of the poorest 25 % (NBS 2011).

The study was conducted in the Chamwino District of Dodoma Region and Kilosa District, Morogoro Region, in Tanzania. The two regions represent the majority of farming systems in Tanzania (USAID 2008). The Dodoma Region is particularly sensitive to food insecurity, whereas Morogoro has both food-insecure and food-secure areasThe Chamwino District is located between latitudes 5°0'0"S to 7°30'0"S and between longitudes 34°00'0"E to 36°30'0"E. Kilosa is located between latitudes 6°0'0"S to 7°50'0"S and longitudes 36°30'0"E to 37°30'0"E (Fig. 2). Four villages were purposefully selected for the study, two from each district. The selection of villages was based on agro-ecological zones, food security (Mnenwa and Maliti, 2010; Liwenga 2003; Mnimbo *et al,* 2017) dimensions, and access to markets. The selected villages were Idifu and Ilolo in Chamwino District, and Changarawe and Ilakala in Kilosa District.

The villages Ilakala and Changarawe are located in the semi-humid (600-800 mm) Morogoro Region. The Morogoro Region is characterised by flat plains, highlands and dry alluvial valleys with mainly loamy soils. The long-term rainfall starts in February and continues into May. The short-term rain season lasts from October until December with much lighter and unreliable rainfalls compared to the long-term rainy season. Agriculture is the main economic activity, and most people engage in farming of both subsistence and cash crops, partly with livestock (Shindler, 2015). The cropping systems are primarily based on maize, sorghum, legumes, rice and horticulture. Sesame and sunflower are major cash crops that are grown by smallholder farmers (Mnenwa and Maliti, 2010). Farmers use mainly animal powers for tillage, but tractors are also used by very few farmers. There is a lack of transformation and value-adding infrastructure, such as oil milling machines. The village Changarawe has relatively good market access and is relatively better off in terms of food availability, whereas Ilakala has relatively poor market access and has exceedingly severe problems of food security.

The other two case study villages, Ilolo and Idifu, are situated in the semi-arid Dodoma Region, located on the central plateau of Tanzania. The landscape is in Dodoma is characterised by flat plains and only small hills. Rainfall (350-500 mm) in this climate is unreliable Shindler 2015; Mnenwa and Maliti; Graef, 2014). The food system is primarily based on sorghum and millet, with a long history of livestock husbandry (Mnenwa and Maliti, 2010). Crop production and livestock, particularly cattle, constitute the mainstay of the economy in providing income, employment and ensuring adequate food supplies. The farmers also grow sunflower and sesame as cash crops. Farmers use mainly animal power for tillage and hand hoes for field preparation. Ilolo is relatively better positioned in terms of market access compared with Idifu (Shindler, 2015). In Morogoro, 18% of men and 24% of women have never had access to education, whereas in Dodoma 33% of males and 40% of females have no education (URT, 2011). Dodoma has the highest rate of stunted under-fives (approximately 80%) among regions in Tanzania. The level of child stunting in Morogoro is slightly above the national average of approximately 60% (URT, 2011). Both regions have a low population density, with fewer than 50 people per square kilometre. The average household size in Morogoro is 4.3 people and in Dodoma 4.6 people per family (NBS, 2014). Dodoma is characterised by a higher level of outmigration compared with Morogoro (URT, 2006).

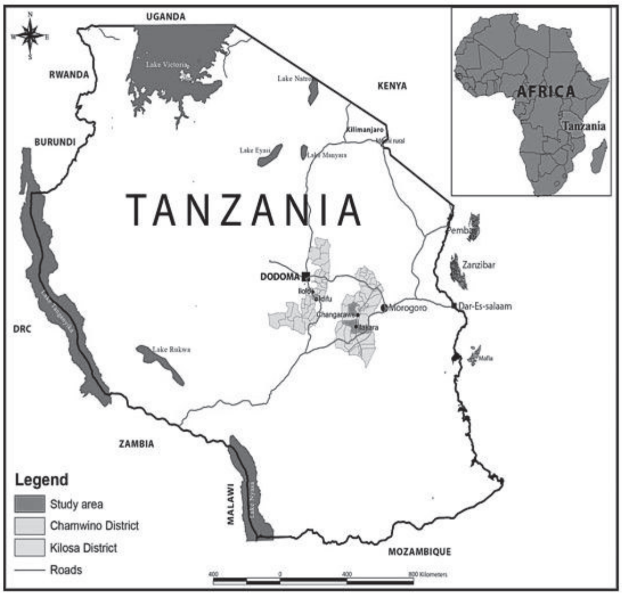

Figure 2. The map showing the study Districts

The study Districts Kilosa is located in Morogoro (Changarawe and Ilakala villages) and Chamwino District is located in Dodoma consisting of Ilolo and Idifu villages.

2.2. Research Design

The study which this paper is based used a cross-sectional research design whereby data were collected once using a mixed methods approach. According to Creswell and Clark (2011), a mixed method is an approach that allows collection, analysis and triangulation of information, from both quantitative and qualitative data in a single study or program of inquiry. In addition cross-sectional designs are well suited to describing variables and patterns of their distribution (Hulley *et al.,* 2013).

2.3 Data Collection

Both quantitative and qualitative data were collected. In collecting qualitative data, a total of 32 focus group discussions (FGDs) administered on the 4 UPS group, gender desegregated making a total of 8 focus group per village (4 villages). Each focus group had 12 participants. The study used three contrasting approaches namely a) a participatory stakeholder approach using FoPIA (Framework for Participatory Impact Assessment tool; (Morris *et al.,* 2011) b) Scientific expert based approach using ScalA-FS (Graef *et al.,* 2016) and (c)The Gender Analysis Matrix. The above approaches are briefly described below.

2.3.1 Scala-FS

Although criticisms of top-down approaches and over-reliance on expert knowledge have been around for some time, methods that measure the differences between local and scientific knowledge remain under-developed (Onianhod *et al.,* 2004; Chambers, 2012). The "scaling up assessment tool for food security" ScalA (Sieber *et al.,* 2015) was adapted and reprogrammed to serve both the food security context and the social, economic, and environmental sustainability dimensions (Agol *et al*., 2014; Schindler *et al*., 2015): Also assessments such as on general UPSth the food security context and the social, economic, and environmental sustainability dimensions.

2.3.2 Adapting the existing FoPIA

FoPIA was selected as the most appropriate for participatory approach on farming interventions (Morris et al., 2011; König et al., 2012; König et al., 2013)(Schindler et al., 2015) FoPIA has not yet been systematically applied at farmers' level or in the food security context. Therefore, it was further adapted it to the needs. Originally, FoPIA was developed for land-use policy impact assessment among policymakers in Europe (Pérez-Soba et al. 2008; Helming and Pérez-Soba, 2011). The framework was described in this regard by Morris et al. (2011). At the same time, the FoPIA framework was adapted by König et al. (2010) and further developed for application in the development context (König et al. 2012; Purushothaman et al. 2012; König et al., 2013). FoPIA provides a series of methods for conducting sustainability impact assessment by following three consecutive steps: 1) scenario development (case study selection, problem definition, scenario narratives of policy induced land management options); 2) specification of the sustainability context (analysis of land use functions, development of land use function assessment criteria); and 3) scenario impact assessment (impact assessment with and without trade-offs) (König et al., 2012).

In order to be applicable at farmers' level, the existing FoPIA was adapted and modified consisting of only two main steps: 1) analysis of the geographical and food security context and 2) impact assessment of local food security upgrading strategies. In this study, we present the result obtained from the refinement of the first part of FoPIA, which addresses criteria development for application at the community level, particularly with smallholders to elaborate food security criteria.

This newly developed tool named ScalA-FS (Scaling up Assessment Tool for Food Security) and FoPIA were used for expert-based ex-ante impacts assessments on a) social criteria such as on food diversity (sufficient, safe, nutritious food); social relations (socio-cultural acceptance); and working conditions (working hours and quality), b) economic criteria such as on production (agricultural yield i.e. kg/ha); income (household income); and market participation (surplus sold in markets or inputs purchase), c) environmental criteria such as on soil fertility (chemical soil properties); available soil water (available water for plants over the growing season); agro-biodiversity (Number of crops and wild species). The assessment scale ranged from -3 to +3 (-3 very high negative impact, -2 medium negative impact, -1 small negative impact, 0 no impact, +1 small positive impact, +2 medium positive impact, +3 high positive impact), while the experts were asked how UPS affected the criteria and its related indicators (y) in Dodoma/Morogoro.

2.3.3 GAM (Gender Analysis Matrix)

This tool was developed by Rani Parker in 1993, and it aimed at helping determine the impact development interventions have on women and men, by providing a community-based technique for identifying and analysing gender differences (Candida, 2003). The GAM tool was used to collect data by looking based impact on four major areas: labour, time, resources (considering both access and control), and socio-cultural factors. The information on impact was collected focusing on women, men, households, and community. Food securing UPS were selected through a participatory process involving both local subsistence farmers and experts (Table 1). 13

food Value Chain-upgrading strategies were selected (This process involved screening and inventorying of UPS in Morogoro and Dodoma regions (the case study sites (CSS)),the expert–based specification and prioritization of UPS, and finally the stakeholder–based prioritisation of 13 UPS for implementation and testing. The later ones were used for this ex-ante impact assessment.

Table 1: Upgrading strategies across FVC components and their selection (✓) in different climate regions

Upgrading strategies	Sub-humid region	Semi-arid region
Rainwater harvesting (RWH): in-situ RWH using tied ridges in the sub-humid region and infiltration pits in the semi-arid region (Mahoo *et al.,* 2012)	√	√
Improved processing devices: mobile maize shelling machines in sub-humid region and millet shelling machines in the semi-arid region, including participatory business plans for investment and pay-offs (Mejia 2003)	√	√
Household nutrition education: increase awareness of nutrient-rich including indigenous foods, and making better use of these crops to improve nutritional status especially of under-five children (Roy *et al.,* 2005).	√	√

2.4 Identification of the Food Criteria

This research supports the need to link sustainability and food security in agricultural development (IAASTD 2009; Cavatassi 2010; FAO 2013)**.** The criteria are related to the 4 internationally recognized food security dimensions (WFP 2013, 2014) All four food security dimensions (availability, access, utilisation and stability) were represented by the locally identified criteria, most being related to "access" and "stability". A total of 13 food security criteria were identified by the farmers across the Ilakala, Changarawe, Idifu and Ilolo villages structured along the three dimensions of sustainability i.e. social, economic and environmental (Table 2). Three criteria (*food diversity, social relations and working conditions*) represent the social dimension while (*yield, income and market participation* represent the economic dimension. Three criteria (*soil fertility*, soil water and *agro-diversity*) represent the environmental dimension. This alignment shows that rural communities think holistically and consider multiple criteria and dimensions when assessing their particular food security situation (Millstone et al. 2010). Organising the criteria along the three sustainability dimensions (social, economic and environmental) facilitated a structured analysis and helped to identify which dimension, social, economic or environmental, was given the highest priority for improving food security and therefore highlighting the need to consider all three dimensions to find solutions (López-Ridaura et al.*,* 2002; Schindler et al., 2015; Hacking and Guthrie 2008; Bond and Morrison-Saunders 2011; Bond et al., 2012). Literature from FAO (2008) suggests that it is important to link the criterias to food security dimensions because all criterion must be fulfilled simultaneously and most of these criteria could not be simply attributed to a single food security dimension. For example: regarding the farmers' definition, interrelations between the dimensions, e.g., the criterion soil fertility is related to the two dimensions availability and stability. Each local community does not set the same priority for each dimension. The criteria, as indicated by the farmers, demonstrate the close interrelationship between sustainability and food security.

Table 2: Food security criteria and explanation (adapted from J. Schindler *et al.*, 2015)

Criterion	Sustainability dimension	Definition (FoPIA, ScalA-FS)	Definition (GAM)
Yield, production	Economic	Amount of food produced and available for family consumption and for selling	**Labor provider(s) (male/female)**
Income	Economic	Family financial resources earned from agricultural production and off-farm activities	**Distribution of earned financial resources from agricultural production and off-farm activities.**
Market participation	Economic	Selling and buying agricultural products and other needs; knowledge of market prices for improved negotiation power of farmers towards buyers	**Who participate in marketing (men and women) and how much time they use in marketing activities.**
Food diversity and availability	Social	Sufficient number of meals (=3) per day offering a diversified and balanced diet	The contribution of men and women in increase or decrease of food. (assurance of three meals a day)
Social relations	Social	Community support during family need (i.e., drought, family incidences such as illness, death) Family support and understanding of decision-making about households resources	**How will the relationship between men and women be affected due to different UPS.**
Working conditions	Social	Access to appropriate technology/equipment and agricultural practices, reducing working hours and workload	Amount of hours spent by men and women in agricultural activity
Soil fertility	Environmental	Quality of the soil for agricultural production	Not defined
Water availability	Environmental	Soil water availability for agricultural production	Not defined
Agrodiversity	Environmental	Cultivation of crop variety for family consumption and for selling; risk management in case of crop failure	Not defined

2.5 Data Analysis

The data from FoPIA and ScalA-FS were analyzed with IBM SPSS statistics 22. The arithmetic average for each region and each criterion were calculated to find the arithmetic average. Minimum and maximum scoring values of the assessed impacts for all selected UPS.

The assessment results for each criterion were numbered on a Likert scale were ordinal scaled from 0 to 3.The scoring results could therefore be considered as quasi-metric (Lisch, 2014) .Since the study villages had non-normal distribution, the nonparametric Mann-Whitney U test was used to analyze similarities and differences.

3.0 Results and Discussion

The three upgrading strategies (Rain water harvesting, nutritional education and kitchen gardening, and shelling/threshing machines (improved processing) and food security criteria were analyzed across the three methodological tools (Scala-FS, FoPIA and GAM) analyzing farmers responses sex wise (men and women) and comparing the two case study areas Morogoro and Dodoma.

3.1 Rain Water Harvesting

3.1.1 Scala-FS

3.1 Rain water harvesting (RWH)

3.1.1 Scala-FS

Expert based ratings on RWH differed widely between all criteria ranging from low negative impact (*working conditions*) to high positive impact, with *soil water*, *crop yield*, *food diversity*, *income,* and *social relations* being given highest ratings. The economic criteria ratings for income and market participation differed between male and female scientists, with females giving generally lower ratings than males both in Chamwino and Kilosa, although this was not statistically significant(Table 3). This variation might be due to female scientist doubting this UPS can bring about a high stipulated change of income. Result on the study conducted in Kenya by (Nyamieri, 2013) revealed that the rainwater harvesting technology is seen by the community members to be a good initiative in improving agricultural practices in periods of water scarcity. However, the technology's sustainability and wide spread adoption seems unlikely, as its success is mainly directed and depended on the social factors. Similar results were observed by (Cosysn *et al*., 2013). Among social criteria, there were rating differences for both regions in social relations and on working conditions with female scientists even indicating a slight negative impact on the latter (Table 5). This difference might be due to the thought of increment of workload brought about by the activities /technologies in RWH with preparation of tied ridges. The environmental criteria for RWH did not differ between the sexes (Table 7) except for agro-diversity in both regions (significant difference for Chamwino, $p < 0.05$).

The ratings differed between sexes of the respondents ($p<0.05$) background of expertise (scientists and farmers) and the preference in the UPS were evident in the ratings. The hypothesis on the difference in ratings by the scientist and the farmers is the difference in the community knowledge whereas the farmers were giving an indigenous based knowledge and the scientist the expert based. The SDs in most cases was higher among the male scientist, especially for *working conditions* and *agro-diversity*, indicating somewhat more contrasting perceptions on the RWH impacts.

3.1.2 FoPIA

Farmer based ratings on RWH were mainly based on social and *environmental criteria*, with *soil water, food diversity, agro-diversity , soil fertility* and *social relations* being ranked to have high positive impact. On the economic criteria, there is a slight difference between sex on income in Chamwino, with female farmers rating higher positive impact on market participation compared to male farmers (Table 3). With regards to environmental criteria (Table 7), both female and male farmers gave overall high ratings in both districts except for agro-diversity. In Chamwino district where men gave only moderate ratings (significant difference at ($p < 0.05$) This difference might be caused by ecological characteristic of Chamwino (350–500 mm of annual precipitation) and that men and women assuming this as a risk management opportunity in case of crop failure. The SDs in Kilosa were low except for Chamwino farmers in assessing agro-diversity (male farmers), yield (female farmers), and market participation (male farmers), indicating somewhat more contrasting perceptions in that agro-climate. According to (Neef and Neubert, 2011 and Jacobsen 2012: Chambers, 2012) In essence, rain water harvesting can supply water to accelerate social and economic development, to alleviate poverty and generate income for rural farmers by enhancing crop yield, modifying the method of production, as well as promoting environmental conservation. The scaling up of such technology will bring about impacts to a larger community through involvement of various stakeholders.

Table 3: Gender related differences in impact assessment of UPS on economic criteria for case study districts Kilosa (M) and Chamwino (D)

		Scala-FS																	
		(1) production. yield						(2) income						(3) market participation					
	a)	female			male			female			male			female			male		
UPS		mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)
Rainwater harvesting (RWH)	M	2.2	±0.8	(6)	2.5	±0.6	(14)	1.8	±0.4	(6)	2.3	±0.6	(14)	1.5	±0.8	(6)	2.0	±0.7	(13)
	D	2.1	±0.7	(7)	2.5	±0.9	(15)	1.7	±0.5	(7)	2.2	±0.9	(15)	1.6	±1.0	(7)	2.2	±1.0	(12)
Improved processing	M	1.8	±1.3	(4)	1.3	±1.0	(14)	2.3	±1.0	(4)	2.0	±0.9	(14)	2.3	±1.0	(4)	2.4	±0.8	(14)
	D	1.8	±1.1	(5)	1.4	±1.1	(15)	2.0	±1.2	(5)	2.3	±0.7	(15)	2.0	±1.2	(5)	2.3	±0.9	(15)
Household nutrition education	M	1,1	±1.0	(7)	0.8	±0.9	(10)	0.4	±0.5	(7)	0.2	±0.6	(10)	0.3	±0.5	(7)	0.1	±0.3	(10)
	D	0.6	±1.0	(7)	0.8	±1.0	(11)	0.1	±0.4	(7)	0.6	±1.3	(11)	0.1	±0.4	(7)	0.5	±1.0	(11)
		FoPIA																	
UPS		mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)
Rainwater harvesting (RWH)	M	2.9	±0.32	(10)	2.6	±0.97	(10)	3.0	±0.0	(10)	2.6	±0.97	(10)	2.9	±0.32	(10)	2.7	±0.68	(10)
	D	2.0	±1.27	(11)	2.14	±0.86	(14)	2.55	±0.52	(11)	2.43	±0.76	(14)	2.64	±0.51	(11)	2.0	±1.18	(14)
Improved processing	M	2.55	±0.52	(11)	2.86	±0.36	(14)	2.0**	±0.63	(11)	2.7**	±0.61	(14)	2.36	±0.92	(11)	2.64	±0.84	(14)
	D	2.67	±0.65	(12)	2.5	±0.91	(12)	2.75	±0.45	(12)	2.17	±1.19	(12)	2.92	±0.29	(12)	2.5	±1.0	(12)
Household nutrition education	M	3.0	±0.0	(13)	2.5	±1.07	(8)	2.62	±0.77	(13)	3.0	±0.0	(8)	2.31	±1.32	(13)	2.13	±1.36	(8)
	D	2.56	±1.01	(9)	2.09	±1.04	(11)	2.44	±1.13	(9)	2.55	±0.69	(11)	2.78	(11)	(9)	2.55	±0.52	(11)

N = number of respondents; rating: -3.0: high negative impact, -2.0: moderate negative impact, -1.0: low negative impact, 0: no impact, 1.0: low positive impact, 2.0: moderate positive impact, 3.0: high positive impact; significance of gender related differences: * significance level α=0.05, ** significance level α=0.01, *** significance level α=0.001 (Mann-Whitney U test). N = number of respondents; rating: -3.0: high negative impact, -2, 0: moderate negative impact, -1, 0: low negative impact, 0: no impact, 1.0: low positive impact, 2.0: moderate positive impact, 3.0: high positive impact; significance of gender related differences: * significance level α=0.05, ** significance level α=0.01, *** significance level α=0.001 (Mann-Whitney U test).

3.1.3 Gender Analysis Matrix

The gender differentiated ratings on RWH upgrading strategy, only cores economic and social criteria, whereby high ratings were given on, time invested in rain water harvest, food diversity, labour/amount of workload attained and farmer for market participation. There is high positive rating by men on economic assessment on labour, men from both districts (Kilosa and Chamwino) ranked labour higher than women although it was not statistically different. This is because, in RWH men experienced more workload than female farmers (Table 4). For example, it was revealed that male farmers are the ones undertaking the role of preparing the tie ridges. Results from GAM on (Table 6) shows there was a highly significant difference on time used to render rain water activities for men and women in Chamwino ($p<0.05$), this is because men used more time in RWH than women. In rating the economic criteria on market participation (Table 3) there was a significant difference between men and women in Chamwino ($p<0.05$) where as in Kilosa men rated RWH high in market participation although not statistically significant. These differences can be assumed to be brought about by the cash crops produced using the RWH technology which sometimes is considered to be men oriented crop (Mnimbo *et al.,* 2017). According to (UNEP, 2009), in agriculture rainwater harvesting has demonstrated the potential of doubling food production by 100% compared to the 10% increase from irrigation.

On the social criteria, there was a significant difference between men and women (P<0.05) in Chamwino on food diversity with men rating higher than women (Table 5). There was a high positive assessment for men and women in both districts on social relations although not statistically significant. This may show that women had other roles to play in the household for example, cooking, fetching water, fetching firewood and taking care of the children in the house. The SDs in few cases was higher in Kilosa for men on (*Labou*r, *time* and *market participation* and *food diversity*) and slightly high for women in Chamwino on *market participation and food diversity.* According to Croppenstedt 2013 and Ezezika *et al.,* 2013) *Rainwater harvesting* has in many cases not only increased human well-being and ecosystem services, but also acted as a way of improving equality and gender balance and of strengthening social capital in a community.

Table 4: Gender related differences in impact assessment of UPS on economic criteria for case study regions Morogoro (M) and Dodoma (D) using GAM

UPS		Labour						Time						Market participation					
		Female			Male			Female			Male			Female			Male		
		mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)
Rainwater harvesting	M	2,3	±0.45	(12)	2.5	±1.04	(10)	2.3*	±0.45	(12)	2.7*	±0.95	(10)	1.9	±0.67	(12)	2.5	±0.90	(10)
(RWH)	D	2.4	±0.61	(30)	2.6	±0.69	(27)	2.1*	±0.44	(30)	2.7*	±0.59	(27)	1.8*	±0.56	(30)	2.9*	±0.28	(27)
Improved processing	M	1.6*	±0.71	(24)	2.9*	±0.28	(24)	1.4*	±0.88	(24)	3.0*	±0.20	(24)	0.8*	±0.71	(24)	3.0*	±0.00	(24)
	D	2.2*	±0.37	(20)	2.9*	0.37	(20)	2.0*	±0.58	(20)	2.8*	±0.38	(20)	2.3*	±0.59	(20)	2.8*	±0.51	(20)
Household nutrition	M	2.7*	±0.61	(28)	2.1*	±0.69	(26)	2.8*	±0.52	(28)	1.8*	±0.75	(26)	2.7*	±0.65	(28)	1.3*	±0.67	(26)
education	D	2.8*	±0.37	(37)	1.9*	±1.14	(35)	2.9*	±0.28	(37)	1.6*	±1.06	(35)	2.7*	±0.88	(37)	1.0*	1.12	(35)

N = number of respondents; rating: -3.0: high negative impact, -2, 0: moderate negative impact, -1.0: low negative impact, 0: no impact, 1.0: low positive impact, 2.0: moderate positive impact, 3.0: high positive impact; significance of gender related differences: * significance level α=0.05, ** significance level α=0.01, *** significance level α=0.001 (Mann-Whitney U test). N = number of respondents; rating: -3.0: high negative impact, -2.0: moderate negative impact, -1, 0: low negative impact, 0: no impact, 1.0: low positive impact, 2.0: moderate positive impact, 3.0: high positive impact; significance of gender related differences: * significance level α=0.05, ** significance level α=0.01, *** significance level α=0.001 (Mann-Whitney U test).

3.1.4 Comparison of ScalA-FS, FoPIA and GAM findings in relation to UPS

Comparing the three assessment tools on UPS, it was found those FoPIA farmers' ratings were mostly high and more optimistic, followed by GAM and then scientists (ScalA-FS) ratings. Also, FoPIA ratings were more homogeneous in terms of ranges of rating of the food security criterion and across the single assessing focus group discussion (lower SDs, which indicates that the data points are close to the mean because the farmer scores/ratings were different), compared to GAM and in particular ScalA-FS. This indicates that the farmer oriented tools (GAM and FoPIA) being highly rated by farmers indicates that the knowledge of ecosystem dynamics gained from historical experience become culturally embedded and are adaptive within the community (Berkes *et al.,* 2000).

3.2 Threshing and Shelling Machines

3.2.1 Scala-FS

Expert based ratings on improved threshing and shelling machines differed ranging from very low rated environmental criteria (*agro-diversity*) to high positive ratings with *market participation*, income, *working condition*, *food diversity (*for female scientist) *and social relations (*for male scientists) being given highest ratings. In both districts, female scientists had high ratings on threshing and shelling machines compared to the male counterparts in both districts (Table 2), this might be due to the assumption that these machines might lead to a better participation and involvement of men and women in agricultural activities and therefore lead to better production results. This was also suggested by Tibaijuka (1994) who reports that new technologies and innovations helps in improving gender roles in agriculture, i.e. a lack of substitutability between men and women for certain tasks, lead to production losses in Tanzania. There was difference in ratings on social criteria (*food diversity*). High ratings for female and low for male scientist although not statistically significant moreover, male scientists rated high positive on the social relation in threshing/shelling, this might be because there is more involvement of men in threshing machines activities than women and therefore the anticipation is that the social networks and relation is anticipated to be more advantageous to men than women. Contrary to this the study by Blackden *et al.* (2006) shows that the adoption and use of improved technologies is positively correlated with education but is also dependent on time constraints. There were low SDs on *agro-diversity* in both Chamwino and Kilosa for female scientist and high SDs on working *conditions* and *social relations* for male scientist in Chamwino.

3.2.2 FoPIA

The ratings by female and male farmers on the criteria ranged from low negative rated (soil water) by male farmers in Chamwino to high positive ratings on *working condition*, *market participation* (only female in Chamwino) and *yield.* Table 3 shows the economic criteria with high significance difference between men and women ratings on income associated with threshing/shelling machine in Kilosa whereby female farmers rated low positive compared to men (*p<0.01*). This indicates that in Kilosa there is less involvement of female farmers on income associated with threshing compared to men and also compared to Chamwino were female farmers had high ratings on income than male farmers, this might be caused by time constraints associated with household chores or engagement in other activities which its income comes directly to women e.g. snacks selling or tailoring. The studies by (Fletschner *et al.*, 2010; Croson and Gneezy, 2009; Browne, 2006) suggest in line with this study that cultural and societal norms and family obligations limit the economic activities in which women can engage. (Table 5) shows on the social criteria there was significant difference in rating for male and female in Chamwino on *food diversity ($p<0.05$)* with female being higher than male this might be because women are generally responsible for food selection and preparation and for the care and feeding of children. The GAM results (Table 6) There is high significance difference ($p<0.01$) in *social relation, with* male farmers being higher than the female farmers in Kilosa, this is because male farmers are more involved with the processing activities and have a lot to communicate and socialize about the machine compared to women for example; the mechanization of the machines, repair and market. *Working condition* criteria was rated high by female and male in both districts this is because of the mobility and operation of the threshing machine. The environment criteria was found to have significant negative impact for *soil water* in Chamwino ($p<0.05$) (Table 7). High SDs were observed for both sexes in Chamwino on market participation and income, for female in Kilosa and male in Chamwino on food diversity, for social relation for female in Kilosa and male in Chamwino. Generally, environment criteria were found to have high SD except for Chamwino which had very low SD on soil water.

Table 5: Gender related differences in impact assessment of UPS on social criteria for case study regions Kilosa (M) and Chamwino (D)

		Scala-FS																	
		(1) food diversity						(2) social relations						(3) working conditions					
	a)	female			male			female			male			female			Male		
UPS		mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)
Rainwater harvesting (RWH)	M	2.0	± 0.6	(7)	2.1	± 1.1	(13)	1.8	± 0,4	(6)	2.3	± 0.6	(14)	-0.9	± 1.6	(7)	0.0	± 2.0	(13)
	D	1.9	± 0.4	(8)	2.2	± 1.0	(14)	1.0	± 1,9	(6)	2.0	± 1.0	(14)	-0.9	± 1.6	(7)	0.3	± 2.1	(14)
Improved processing	M	2.2	± 0.4	(5)	1.6	± 0.9	(12)	1.3	± 1,7	(4)	2.0	± 1.2	(12)	2.2	± 1.1	(5)	2.3	± 0.9	(12)
	D	2.0	± 0.6	(6)	1.9	± 0.7	(14)	1.3	± 1,7	(4)	2.2	± 0.7	(13)	1.5	± 1.5	(6)	2.4	± 1.1	(14)
Household nutrition education	M	2.4	± 0.8	(8)	2.8	± 0.6	(10)	2.2	± 1,3	(6)	2.2	± 0.9	(10)	1.0	± 1.1	(8)	1.0	± 1.2	(10)
	D	2.7	± 0.6	(8)	2.9	± 0.5	(11)	2.2	± 1.3	(6)	2.5	± 0.8	(11)	0.8	± 1.0	(8)	1.9	± 1.4	(11)
		FoPIA																	
UPS		mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)
Rainwater harvesting (RWH)	M	3.0	±0.0	(10)	3.0	±0.0	(10)	2.7	±0.48	(10)	2.9	±0.61	(10)	2.9	±0.32	(10)	2,8	±0.42	(10)
	D	2.91	±0.3	(11)	2.43	±0.76	(14)	2.55	±0,82	(11)	2.57	±0.94	(14)	2.82	±0.41	(11)	2,36	±0.84	(14)
Improved processing	M	1.73	±1.27	(11)	2.57	±0.85	(14)	1.5**	±1.37	(11)	2.8**	±0.8	(14)	3.0	±0.0	(11)	2.86	±0.36	(14)
	D	2.83*	±0.39	(12)	1.67*	±1.37	(12)	2.33	±0.99	(12)	2.33	±1.23	(12)	2.83	±0.58	(12)	2.5	±0.8	(12)
Household nutrition education	M	2.77	±0.6	(13)	3.0	±0.0	(8)	2.77	±0.44	(13)	3.0	±0.0	(8)	2.54	±0.97	(13)	3.0	±0.0	(8)
	D	2.56	±1.01	(9)	2.91	±0.30	(11)	3.0	±0.0	(9)	2.36	±1.03	(11)	3.0*	±0.0	(9)	2.45*	±0.69	(11)

N = number of respondents; rating: -3.0: high negative impact, -2.0: moderate negative impact, -1.0: low negative impact, 0: no impact, 1.0: low positive impact, 2.0: moderate positive impact, 3.0: high positive impact; significance of gender related differences: * significance level α=0.05, ** significance level α=0.01, *** significance level α=0.001 (Mann-Whitney U test).

3.2.3 Gender analysis matrix

The GAM ratings for men and women on threshing and shelling machines shows the low negative ranked criteria to be *market participation* and l*abor* (by women) and *time* by men and women in Kilosa. The highly positive rated criteria includes social relations, food diversity and labour and market participation (Chamwino).On the economic criteria, there was a significant different of ratings in labour, time and market participation ($p<0.05$) (Table 3) in Chamwino, in which there were higher ratings for male than female on the threshing/shelling machines (Table 4). This might mean a change of gender roles, because formally, these processing activities were done by women (Mnimbo *et al.,* 2017), other reasons could be the assumption that women are involved in other multi-dimensional activities in and outside the household and that women are more risk averse than men. Although results from GAM shows men to use more time than women on threshing and shelling (Table 6), the findings from FAO (2013) confirms the popular perception that women overwhelmingly provide the greatest proportion of household time spent on food processing and preparation. If these aspects of food preparation are included, women. labour share could well exceed 60 percent in many African countries and could approach 60 percent in many Asian ones.

Contrary to this study, Lambrecht *et al.* (2016) suggest that female participation is not conducive to promoting adoption of capital-intensive technologies, but it is for labor-intensive technologies and traditionally female-dominated crops. This may be due to the fact that men often dominate the decision making space of capital-intensive purchases, whereas women are responsible for manual tasks such as weeding and planting. In general, the SD are high in Chamwino compared to Kilosa, sex wise men had lower SD in market participation in Kilosa.

Table 6: Gender related differences in impact assessment of UPS on social criteria for case study districts Kilosa (M) and Chamwino (D) using GAM

UPS		(1) Food diversity						(2) Social relations					
		Female			Male			Female			Male		
		mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)
Rainwater harvesting(RWH)	M	2.3	±0.45	(12)	2.6	±0.39	(11)	2.6	±0.7	(12)	2.5	±0.5	(11)
	D	1.8*	±0.59	(22)	2.8*	±0.39	(23)	2.7	±0.56	(22)	2.5	±0.51	(23)
Improved processing	M	2.0	±0.60	(12)	1.9	±0.92	(14)	2.4	±0.80	(12)	2.3	±0.69	(14)
	D	2.6	±0.51	(25)	2.5	±0.51	(25)	2.8	±0.44	(25)	2.6	±0.58	(25)
Household nutrition education	M	2.6	±0.70	(11)	2.0	±0.82	(13)	2.8*	±0.37	(11)	2.2*	±0.73	(13)
	D	2.7	±0.46	(38)	2.1	±1.19	(35)	2.9*	±0.34	(38)	2.4*	±0.64	(35)

N = number of respondents; rating: -3.0: high negative impact, -2.0: moderate negative impact, -1.0: low negative impact, 0: no impact, 1.0: low positive impact, 2.0: moderate positive impact, 3.0: high positive impact; significance of gender related differences: * significance level: low negative impact, 0: no impact, 1.0: low positive impact, 2,0: moderate positive it). The household for production, as well as promoting environment,0: moderate negative impact, -1.0 : low negative impact, 0: no impact, 1.0: low positive impact, 2.0: moderate positive impact, 3.0: high positive impact; ignificance of gender related differences: * significance level related differences: * signific=0.01, *** significance level α=0.001 (Mann-Whitney U test).

3.2.4 Comparison of ScalA-FS, FoPIA and GAM findings

In comparison between Scala-Fs, FoPIA and GAM assessment tools on processing, it was found that the farmer ratings in FoPIA were the highest region wise and also had high ratings on food security criteria, followed by GAM ratings and then the scientist ratings on Scala-FS. High SD's were in Scala-FS and FoPIA while GAM had overall very low SDs in all food security criteria (the Low SD indicates that most of the ratings were very close to the average mean).

3.3 Nutritional Education and Kitchen Gardening

3.3.1 Scala-FS

Expert based ratings on kitchen garden and nutritional education differed across the criteria ranging from low rated in environmental criteria (*soil fertility, soil water and agro-diversity)* and economic criteria (*yield, income and market participation*) and *working condition*, to moderate on *food diversity and* social relations in both regions. Table 7 shows there was generally low negative ratings by female and male scientist on soil fertility and soil water although not statistically significant based on chi-square .There was significant difference for female and male in Chamwino on agro-diversity (*$p<0.05$)* this might be because of ecological reasons (semi-aridity).The negative ratings for nutritional education and kitchen garden by scientist on the food security criteria might be caused by the anticipation that farmers may not have difficulties getting the improved seed varieties and go back to the traditional ones (sustainability). A study by (FAO, 2011; Vijayalakshmi and Thooyavathy, 2012) on the Sahelian countries (where annual rainfall is below 500 mm) shows similar observation on kitchen garden on agro-diversity by reporting that the biological diversity and complexity of home gardens decline with the transition from humid to semi-arid and arid areas. And that insufficient water is a major constraint to successful gardening in dry areas, yet, even in these areas, crops can be kept growing through effective soil and water management. High SD was observed, for female scientist in relation to yield in Kilosa, for male scientist on *market participation* ,*income* and *agro-diversity* in Chamwino, for female on *social relations* and in general for both men and women in Kilosa and Chamwino on *working conditions.* Low SD on *soil water and soil fertility criteria for* female in both districts.

3.3.2 FoPIA

The farmer based ratings for kitchen gardening on the food security criteria ranged from low ratings on *soil fertility* and *soil water* to high ratings on *agro-diversity*, *social relations*, *working condition, food diversity* and *income.* There are different ratings between men and women in both districts whereby women ratings on yield are slightly higher compared to men although not statistically different (Table 3).On the environment criteria (Table 7),there is a negative rating for soil water for female and male farmers, which means that lack or less of water availability could affect the soil and hinder the proper growth of the kitchen garden. There is a high statistical significance between female and male farmers in Chamwino high ratings for soil water ($p<0.01$).The high ratings might be due to the dry spells in Chamwino and proximity to water sources which is quiet challenging in Chamwino compared to Kilosa. According to Keller (2012) kitchen garden depend on the natural ecology of the location, available family resources such as labor, and the skills, preferences, and enthusiasm of family members. There were high ratings for male and female farmers for *working conditions* in Chamwino with a significance difference of ($p<00.5$) (Table 3) which means the working condition might be the same for male and female. Keller (2012) points out that in some cultures, women are the sole caretakers of kitchen gardens and the activities associated with it while, in others, they play more or less a supportive role. There were high positive ratings for male in Kilosa for *working conditions* although not significant different. This might be due to the reason that female farmers work on the kitchen garden more than male and therefore they face the situations associated with kitchen gardening more. In line with these results, Howard's (2006) analysis of 13 kitchen gardens case studies in South America revealed that women are the main managers of kitchen gardens across the region because the activities are vital and fit well with their day-to-day domestic activities and employment patterns along with their cultural and aesthetic values. The social relations (Table 4) were highly rated in both regions except for men in Chamwino had moderate ratings.The reason might be because in Chamwino the new species of fresh vegetables like amaranthus (*Amaranthus retroflexus*) and night shed (*Solanaceae*), African spider plant (*Cleome gynandra*) are mostly preferred compared to their traditional species example dried green-pea leaves (*safwe*) and *chiwandagulu* and also kitchen garden means less water use and less space consumed as they are also livestock keepers. Studies by (Neef and Neubert, 2011; Shindler, 2015) shows that the realities of farmers are local, complex, dynamic and diverse.

SD difference between Kilosa and Chamwino where observed. Men and women in Chamwino and men in Kilosa had high SD on *yield* (*income* for women in Chamwino). Men and women in Kilosa had high SD on *market participation* compared to men and women scientist in Chamwino. There is high SD for men and women in both regions on soil fertility and soil water (excluding women in Dodoma on soil water) and for women in Dodoma on *food diversity* and *social relations*. Low SD were observed on *agro-biodiversity* in both regions, on female farmers in Kilosa on food diversity, on female farmers in Dodoma and male farmers in Kilosa on *social relations* and *working condition*.

Table 7: Gender related differences in impact assessment of UPS on environmental criteria for case study regions Kilosa (M) and Chamwino (D)

		Scala-FS																	
		(1) soil fertility						(2) soil water						(3) agrodiversity					
	a)	female			male			female			male			female			male		
UPS		mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)
Rainwater harvesting (RWH)	M	1.6	± 0.5	(5)	1.3	± 1.4	(13)	2.3	± 0.8	(6)	2.8	± 0.8	(14)	0.8	± 0.8	(5)	1,7	± 1.2	(12)
	D	1.3	± 0.5	(6)	1.4	± 1.3	(14)	2.4	± 0.8	(7)	2.7	± 0.5	(15)	0.5*	± 0.8	(6)	1,7*	± 1.3	(13)
Improved processing	M	0.5	± 1.0	(4)	0.4	± 1.0	(12)	0.3	± 0.5	(4)	0.2	± 0.6	(12)	0.0	± 0.0	(4)	0,3	± 0.7	(12)
	D	0.4	± 0.9	(5)	0.2	± 0.6	(13)	0.2	± 0.4	(5)	0.2	± 0.6	(13)	0.0	± 0.0	(5)	0,1	± 0.3	(12)
Household nutrition education	M	0.0	± 0.0	(7)	0.4	± 0.8	(10)	0.0	± 0.0	(7)	0.4	± 0.8	(10)	0.4	± 0.8	(7)	1,0	± 0.7	(10)
	D	0.0	± 0.0	(7)	0.3	± 0.7	(10)	0.0	± 0.0	(7)	0.4	± 1.0	(10)	0.3*	± 0.8	(7)	1,2*	± 1.1	(10)
		FoPIA																	
UPS		mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)	mean	SD	(N)
Rainwater harvesting (RWH)	M	2.9	±0.32	(10)	2.7	±0.95	(10)	3.0	±0.0	(10)	3,0	±0.0	(10)	2.9	±0.32	(10)	2.9	±0.32	(10)
	D	2.91	±0.3	(11)	2.86	±0.36	(14)	3.0	±0.0	(11)	2,93	±0.27	(14)	3.0*	±0.0	(11)	2.3*	±1.12	(14)
Improved processing	M	1.64	±1.21	(11)	1.5	±1.45	(14)	0.91	±1.38	(11)	1,71	±1.54	(14)	1.64	±1.43	(11)	1.93	±1.39	(14)
	D	1.67	±1.44	(12)	3.75	±1.36	(12)	1.2**	±1.34	(12)	0,0**	±0.0	(12)	2.25	±1.14	(12)	2.08	±1.38	(12)
Household nutrition education	M	0.69	±1.32	(13)	1.88	±1.55	(8)	0.69	±1.32	(13)	1,5	±1.6	(8)	3.0	±0.0	(13)	3.0	±0.0	(8)
	D	0.67	±1.32	(9)	0.73	±1.27	(11)	0.7**	±1.32	(9)	2,6**	±0.93	(11)	2.78	±0.68	(9)	3.0	±0.0	(11)

N = number of respondents; rating: -3.0: high negative impact, -2.0: moderate negative impact, -1.0: low negative impact, 0: no impact, 1.0: low positive impact, 2.0: moderate positive impact, 3.0: high positive impact; significance of gender related differences: * significance level le and therefore icance level: high positive impact; significance of gender related differ

3.3.3 Gender Analysis Matrix

The ratings among the five criteria on kitchen garden range from highly rated social relations, food diversity and labour (for female in Kilosa and Chamwino) and Low ratings for male farmers on time aspects and market participation in Kilosa and Chamwino. In Chamwino men ratings were negatively low on labour, which shows that women performed more tasks associated in kitchen gardening (Table 3). A study by Keller (1999) reported that all Tanzanian societies have proverbs on gender relationships One example is from Tarime: "The wife is the most important implement in the house which is supposed to be used intelligently and wisely" this might be the case in Chamwino. There is a significance difference in ratings between men and women on social relations in both regions (p<00.5) (Table 5) with women rating high compared to men. The reason for the high ratings on the mentioned criterion is that societal and cultural norms may impose on women the role of ensuring adequate share of food among household members and that women opt to spent more time in their kitchen gardens in order to be relieved of the drudgery of travelling a distance of 6-10 kms to buying vegetables or waiting for the bicyrcle-vegetable vendors to pass by which is never certain. Similar results were observed on studies by FAO,(2011), Quisumbing and Pandolfelli (2010) were as kitchen gardens were reported to have become a source of strengthening family and social bonding because men and women help each other to take care of the pocket garden in the household and they exchange vegitables with neighbours and sometimes helping them earn reasonable income. High SD's were observed for men in Dodoma on labour, time and market participation and on food diversity.

3.3.4 Comparison of ScalA-FS, FoPIA and GAM findings

Tool wise overall rating for nutritional education and kitchen gardening UPS, shows the farmer oriented tool (FoPIA) had high ratings followed by GAM and the scientist ratings (Scala-FS) on the food security criteria. Lower SDs were observed in GAM tool while Scala-FS and FoPIA had high SD interchangeably between districts and sex inducing a high hypothesis support upon issues discussed between men and women.

3.6 Synthesis of all UPS Impact Assessments

3.6.1 Gender oriented findings across food criteria and UPS

The ratings of in Chamwino and Kilosa study sites on food criteria and UPS were found to be gender and geographical specific (Mnimbo *et al*., 2017). In Chamwino results show the highly rated food criteria to be economic and social criteria. The two criterions were rated high on the UPS that involved social interaction of activities and that have direct connection with income, time or yield. *For example;* women highly rated *social criteria* on (nutritional education and kitchen gardening) for example; there 8 high ratings in all of the expert based Scala-FS tool and 4 of these ratings are on social criteria rated by men followed by economic criteria (*on threshing/shelling machine*) rated highly be men on *time* and *labour* compared to women. The processing activities like threshing, shelling and winnowing, which were traditionally done by women in both districts (Mnimbo *et al.,* 2017) are now done by men because of the invasion of machine. Similar results were observed by (Farnworth *et al*., 2016) that when there is a new technology the gender roles change. The reasons for the above ratings on food security criteria can be assumed to be due to ecological reasons (on the environmental criteria), the community observation on the importance of cultural interactions and socialization and financial, time and infrastructural aspects.

3.6.2 Difference in tool specific findings

There are interesting differences between the two ex-antes (Scala-FS and FoPIA) and the ex-post tool assessment (GAM). FoPIA and GAM to had similar high assessment across the food security criteria. The Scala-FS generally shows lower ratings on all three UPS most especially in nutritional education and kitchen gardening, FoPIA and GAM had higher ratings in nutritional education and kitchen gardening and RWH, threshing and shelling machines were moderately rated in these two tools. Interestingly for Scala-FS, all the high rated food criteria on the UPS were rated by male scientist (soil water, food diversity and yield) except for food diversity which was ranked high by female scientist in Chamwino. In the GAM and FoPIA tools male rank processing high than women. According to (Quisimbing, 2014: Farnworth 2016) A holistic approach toward addressing food security enables the understanding of local meanings and might reveal important and unnoticed aspects of resource allocation, as well as provide guidance for initiatives that seek to provide locally relevant approaches to improving gender equity.

3.6.3 Methodological findings

All three methodological approaches Scala-FS, FoPIA and GAM supported a constructive and interactive way that enables getting both the perspectives from scientific expert and from the actual farmer on the ground, and as such they complement each other. With the combination of the gender based tool like GAM, the study is enriched by enabling to capture the inter-household and intra-household perspectives. Bringing into a context a gendered lens is of essential because otherwise unsound gender analyses can miss the point, resulting in flawed understanding of the real issues and ineffective or even damaging interventions (Coles and Mitchell, 2010). Essentially the tools were based on cross-sectional data to the exclusion of time series, and presented static ex ante and ex post gender information on food security criteria and on the UPS consequently, but the tools failed to adequately project the impacts of the UPS on food security over a longer time horizon. As noted by some experts, however, changes in intensity of production and improvement of food security are best evaluated over time and at locations where UPS (like the threshing/shelling machines and the use of RWH) use and density have established a mature equilibrium (Jones *et al*., 2013). The study did not quantify the benefits from non-agricultural use of the technologies(threshing/shelling machines, kitchen garden and RWH) for example supplementary income from machinery hiring services, this is because non-agricultural use of equipment is essential in order to ensure utilization rates that justify the required capital investments (Vink, 2012).

4.0 Conclusions and Recommendations

The tools used in this study were found to complement each other and bring out the ways in which different representations of the community (farmers)and scientist (expert) are organized, and socially influenced make them useful for understanding the food security criterion (economic, social and environmental). The use of holistic participatory approach in food security is crucial because food issues are context specific; communities have their own priorities in improving their livelihood situations and so doe’s scientist.

It was observed in the study that economic criteria and social were highly rated by the farmers because farmers tend to rate higher the criteria involving the UPS that involved social interaction of activities and that have direct connection with income or yield. Generally, the food criterion are found to be interrelated and it was observed that gender wise farmers favor /adopt to what is perceived to have causal-effect connections to them as individuals (For example, to increases in future income streams, evidence on productivity which in turn might lead to being food secured and reducing workload). Therefore the intentions to reduce food insecurity which may or may not coincide with these predicted outcomes may create positive or negative feedback, which would either support the adoption of successful upgrading strategies or create individual change respectively.

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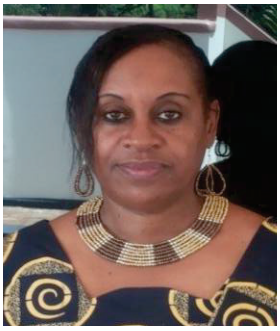

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