Contract number: 031A249A

Work package number 5 and 6
Month 22, 40; year 2016, 2017
Deliverable 5.2.2 & 6.2.2

D5.2.2 Report on ex-post impact assessments of the on-farm field testing
&
D6.2.2 Report on impact assessments of upgrading strategies on a) post-harvest processes and bioenergy production, b) waste product utilization, and c) additional biomass utilization

- MSc thesis by Enrique Alberto Hernandez Lopez -

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Academic year 2014-2016

IMPACT ASSESSMENT OF UPGRADING STRATEGIES FOR FOOD SECURITY: CASE STUDY TANZANIA

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Thesis submitted in partial fulfilment of the requirements
for the joint academic degree of International Master of Science in Rural Development from Ghent University (Belgium), Agrocampus Ouest (France), Humboldt University of Berlin (Germany), Slovak

University of Agriculture in Nitra (Slovakia) and University of Pisa (Italy) in collaboration with Wageningen University (The Netherlands),

This thesis was elaborated and defended at Humboldt University of Berlin. Within the framework of the European Erasmus Mundus Programme "Erasmus Mundus International Master of Science in Rural Development " (Course N° 2010-0114 – R 04-018/001)

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Acknowledgment

To my family,

To my friends,

Thanks.

Exceptional thanks go to CONACYT for their sponsorship,

and to Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) and to their project Trans-SEC for allowing me participate in their teams and their heart warming support throughout this thesis.

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Abbreviations

FoPIA - Framework for Participatory Impact Assessment

AVC Agricultural Value Chain

FVC Food Value Chain

IA - Impact Assessment

CGIAR – Consultative Group on International Agricultural Research

CSS – Case study sites

FAO – Food and Agriculture Organization of the United Nations

FVC – Food value chain

IFAD – International Fund for Agricultural Development

ILRI – International Livestock Research Institute

LDC – Least Developed Country

NE – Nutrition Education

NGO – Non-governmental Organization

OECD – The Organization for Economic Co-operation and Development

RWH – Rainwater harvesting

SPSS – Statistics Software

MDG- Millennium Development Goals

UNDP - United Nations Development Programme UNEP – United Nations Environment Programme

UPS – Upgrading Strategies

URT – United Republic of Tanzania

WFP – World Food Programme

WHO – World Health Organization

HH – Household

MWUt – Mann Whitney U test

KWt – Kruskal Wallis test

1. Introduction

1.1. Problem Statement

Food insecurity remains as a challenge for humankind. A series of complexly related threats undermine the provisioning of food at a global level. Those threats include price fluctuations, environmental degradation, climate change, plant diseases, population growth, changing/homogenization of diets, land competition with bio-fuels, industry and urbanisation, food waste, political instability, among others (Foley 2005; Ziervogel, Ericksen 2010; Isakson 2014; Kornher, Kalkuhl 2013). This challenge is particularly difficult for many developing countries.

Although significant improvements were achieved over the last decades, the number of people undernourished still is considerably high. The latest reports show that one in nine people are unable to consume enough food for a healthy and active life; that is 795 million people worldwide (FAO et al. 2015, p. 17). These numbers are disproportionally represented in developing countries, where more than 98% of those people live. The achievements were significantly different across regions. Latin America and Eastern and South-Eastern regions of Asia were the best performers while improvement in Southern and Eastern Africa was slow and unable to meet the MDG.

Sub-Saharan Africa is the region with the highest prevalence of undernourishment. Almost a quarter of the population (23.2%) suffer this condition, which represent 220 million hungry people (FAO et al. 2015, p. 12). What's more the sub region Eastern Africa has in absolute terms the biggest amount of people undernourished with 124 million (ibid. p.13).This problem even worsened during the last decades. Factors associated with high population growth, rising food prices, droughts and political instability all contributed to this outcome. On the other hand countries in this region that experienced relatively better results enjoyed overall economic growth, political stability and growing primary sectors, mainly agriculture, fisheries and forestry. Moreover the role of social protection policies was significant.

In the sub region Eastern Africa Tanzania represents a particular case. Tanzania has enjoyed annual GDP growth of 2.3% over the last decade; nevertheless this growth has not reduced the number of hungry people in the country. Although extreme poverty declined significantly from 1992 to 2012 with a change from 72% to 44%, the number of undernourishment increased from 6.4 to 17.0 million people in the period 1990-92 to 2012-14 (FAO et al. 2015, p. 30).

Tanzania is not exempt of the general threats mentioned above. Moreover, as well as other countries in the region, certain patterns of determinants leading to food insecurity are present. First, the main disconnection between growth and poverty and food insecurity can be largely attributed to trade liberalization policies and privatization efforts, that were not followed by policies of inclusion and modernization of the agricultural sector (FAO et al. 2015, p. 30). Second, farmers in Tanzania depend both on agriculture and livestock for food security, thus regarding the livestock sector low veterinary services, lack of access to inputs and animal illness restrict the development of this sector (Covarrubias et al. 2012, p. 49). Third, climate change severely affects semi arid regions in Tanzania undermining food security, agricultural productivity and livelihoods resilience (Lema M., Majule 2009, p. 207). Fourth, gender imbalances related to assets ownership in Tanzania are correlated to increased food insecurity of female headed households (Mason et al. 2015, p. 548). Fifth, governance of natural resources is weak, thus destabilizing the safety nets that the environment provides to vulnerable groups. Moreover the infrastructure investments and institutional reforms need further development to encourage growth in the national market. Further, in order to participate in the national or international market, there is a need for enhancement of human capital by public programs on education health and wellbeing (Paavola 2008, p. 651). Sixth, soil and water conservation efforts need further development; promotion, use of local knowledge and local perceptions to develop strategies can encourage adoption, thus increasing food security (Tenge et al. 2007, p. 335). Summing up, Tanzania has plenty of room for improvement, where economic growth, agricultural development and natural resources management stand as an important platform to reach the SDG.

The overall development of the economy has great impact on food security outcomes. However, only *inclusive* economic growth is a key success factor to improve food security, thus strategies that enhances productivity and income of smallholder family farmers will lead to sustainable achievements (FAO et al. 2015, p. 42). Most of the food insecure in Tanzania are rural populations engaged in agricultural production or depending on wages derived from agricultural related activities (URT 2013; MUCHALI 2012). Thus agricultural development strategies have the highest probability of alleviating food insecurity problems.

One of the possibilities to strategize development strategies for food security is the Food Value Chain approach (FVC) (Gomez et al. 2011; Riisgaard et al. 2010; Hawkes, Ruel 2011).The use of this analytical approach provides several benefits. For example it identifies incentives by mapping the movement of value along the chain, thus all actors in the chain could take informed decisions. Further, since it is fundamentally market oriented it provides a diversification strategies for farmers, thus it may increasing their food access and availability. Moreover, because it looks at every link between the producer and consumer, it could be said that it is an inherently systemic analysis (Graef et al. 2014).

Development strategies for food security should closely consider the local specific context. Considering local traditions and knowledge for strategies development ensure better rate of adoption, adaptation and local ownership. Equally important is the symbiosis of knowledge between local actors and scientific knowledge that could generate appropriate pathways for food security (Schindler et al. 2016). Further, there is evidence that suggest that the combination of active local participation and site-specific strategies can increase success (König et al. 2012). In brief participatory processes of strategy development and impact assessment are one of the most important conditions for projects in general and in food security particularly (Schindler et al. 2015).

Assessment of outcomes is crucial to prove the efficacy of development strategies. In this sense impact assessment is an essential tool for this purpose (Pope et al. 2013). Impact assessment is practiced mainly in six areas environmental impact

assessment (EIA); strategic environmental assessment (SEA); policy assessment; social impact assessment (SIA); health impact assessment (HIA); and sustainability (impact)assessment. Sustainability impact assessment is a “recent framing of impact assessment that places emphasis on delivering positive net sustainability gains now and into the future” (Bond et al. 2012, p. 53)

In their analysis of methods to assess farming sustainability in developing countries Schindler et al.(2015) argues that only methods that “(a) integrate equally all three sustainability dimensions, (b) respect their interrelations, (c) involve stakeholders actively at every step of the assessment process, and (d) also focus on exchange and learning” (ibid p.1054) could be considered holistic methods of sustainability impact assessment. One of the methods proposed is the FoPIA approach.

FoPIA is a method for assessing scenario impacts through the conduction of a holistic sustainability impact assessment. FoPIA was originally developed for the European land use policy assessment (Morris et al. 2011) and then further developed for its use in developing countries (Koning et al 2010) and food security (Schindler et al. 2016) . Depending on the context of its use, some of the advantages of the method are the enhancing of regional understanding and key linkages between 1) policy effects, 2) sustainable development, 3)food security, 4)value chain interaction; additionally stakeholders might benefit through the provision of platform for social learning and interaction provided by FoPIA, particularly in data-poor situations.

1.2. Objectives

In this context this thesis has the purpose of using the results of two FoPIA assessments to analyze impacts of development strategies for food security implemented in Tanzania. This endeavour would be the first study that analyzes and compares the results of the two focus group assessments (2014-2015) in order to evaluate the results of the UPS implemented in the framework of the Trans-SEC project. Analyzing these results would be the knowledge gap that this thesis will address.

Moreover, this thesis stand on knowledge developed by the Trans-SEC project "Innovating Strategies to safeguard Food Security using Technology and Knowledge Transfer: A people-centred Approach" which is a project implemented by Leibniz-Centre for Agricultural Landscape Research (ZALF) e.V. The objective of Trans-SEC is the improvement of the food situation for the most-vulnerable rural poor population in Tanzania. This purpose is achieved by designing and identifying successful food securing upgrading strategies (UPS) and/or innovations along local and regional FVC. Trans-SEC is using the FoPIA method for identifying and assessing the impacts of the UPS.

The general objective of the thesis is to evaluate and compare the impact of selected upgrading strategies on locally developed food security criteria in four rural villages in Tanzania.

Specific Objectives

For this purpose, results of two participatory impact assessments from 2014 and 2015 are analysed. These results gathered perceptions and experiences that were analyzed among two focus group missions (FoPIA 1 and FoPIA 2). In order to accomplish the general objective, the following specific objectives are considered in detail:

1) Compare and analyse local preferences, impact arguments and scorings from 2015 vs 2014 of the UPS impact scores across four villages in two climatically different regions
2) Analyse possible reasons of UPS impact scores in order to trace potential mechanisms that affect assessments, perceptions, strategy selection and, finally, food security.

1.3. Research Question

To assess what has been the impact on farmer's experience and perceptions of food security, regarding the implementation of upgrading strategies across the food value chain, the following questions will be discussed:

RQ1: Are there significant differences between stakeholder's perceptions between 2014 and 2015?

Rq2. What are the reasons behind changes in perception between 2014 and 2015?

This approach will facilitate the quantitative assessment of UPS impacts from 2014 to 2015, as well as analyzing the farmers' qualitative argumentation of changes in impacts from one period to the next. Additionally this approach will help to differentiate impacts between farmers, villages and regions characteristics.

1.4. Outline of the study

The thesis has been divided in eight chapters. In this first chapter an introduction to the problem and a review of objectives and research question is presented. Following in chapter two, a review of literature on the concepts employed throughout the thesis, which are food security, value chain approach and impact assessment. This will provide the conceptual framework. Next, the UPS implemented in the case study sites (CSS) as part of the Trans-SEC project will be discussed in chapter three. This chapter will serve the purpose of an overview to the strategies developed and their implementation status among villages. Also in chapter three a description of the CSS will be provided. This first three chapters offer the background for the methodology in chapter four. Results are presented in chapter five. Discussion of the findings and relevant conclusions are presented in chapter six. Finally the document finalizes with a brief conclusions and summary of the thesis in chapter seven and eight.

2. Theoretical Framework

2.1. Food security

Food security is the overall concept along the thesis. This concept is analyzed within the FVC framework (2.2).In this section I will discuss the meaning and drivers of food security, with an emphasis in Tanzania.

Definition

Food security is a multi-dimensional phenomenon. Drivers, determinants, relations are interrelated creating a complex web of interactions that make this concept difficult to grasp and define. Already in 1992 Maxwell, Smith reported about 200 definitions. As a concept, food security appeared in literature around 1960s. At this time it was perceived mainly as the "ability to meet aggregate food needs in a consistent way" (Von Braun et al, 1992 p.14).Anderson, Cook (1999) considered that the concept appeared as a consequence of the food crises resulting from the increase in prices over the period of 1972-1974.Under this background, the availability and access dimensions were emphasized. Nevertheless, Maxwell, Frankenberger(1992) argued that a sole indicator could not capture the multidimensionality and complexity of the concept. Thus, as a multidimensional concept, interrelations of technical, economical, historical, cultural, and political realms influence any outcome (see: Taylor 1981; Friedmann 1995, 1999; McMichael 2009)

Nowadays the definition put forward in the World Food Summit in November 1996 seems to be accepted widely in the literature. This definition will be used as well in this thesis. Thus is considered that, "Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO 1996)". From this definition four dimensions can be identified, that is, availability, access, utilization and stability (Ziervogel, Ericksen 2010). Ability is directly related to the supply side. Supply is a function of the characteristics, physical, social, economical, natural and political, that limits or enhances the productive capacity of food stuff. In addition, the level of stocks will have an effect on the capacity of a given population to access food items when needed. If stocks are low food insecurity is an outcome. Finally, as part of FAO (1996) definition, trade flows are a determinant of food availability. Net trade influence availability in different ways, for

example tariffs or quotas may limit the availability of certain products on the market. In brief all dimensions must be satisfied at the same time to achieve food security.

Devereux (2006) distinguishes two types of food insecurity; chronic food insecurity and transitory food insecurity. In order to distinguish from the two four comparisons could be made, that is, “persistence”, “ability in function of time”, “consequence of”, and “recommended measures”. First, the persistence of the situation refers to the temporality of the situation. If persistent is then categorized as chronic food insecurity. Second, the ability in function of time refers to the capacity to meet the food requirements. If the food requirements are not meet for a sustained period of time, then is considered chronic food insecure; if there is a sudden drop in the ability to meet their requirements, then, is consider transitory food insecure, for example, a drought. This example leads to the third comparison, which is the “consequence of”. If the insecurity results from a short term shock or fluctuation then is consider transitory food insecurity; if is a result of extended periods of poverty, lack or inadequate resources or capital, then, is consider chronic. Lastly, when the recommended measures are structural, like education, physical infrastructure, productive resources, credit etc. then, is considered chronic; on the contrary when is transitory the recommendations are more difficult. In this case safety nets and build capacities are relevant.

In order to categorize a country level of food security the Integrated Food Security Phase Classification (IPC) could be used. IPC is a set of standardized tools that provides a common framework for classifying the severity and magnitude of food insecurity. Thus, allowing comparability of situations across countries and over time. Trough colour coded classification food insecurity is measured. Enabling organization, documentation, and examination of evidence in order to categorize the severity of acute food insecurity and identify immediate causes. Diagram 1 explains in detail the severity phases (FAO 2012).

Phase Name and Description	Phase 1 None	Phase 2 Stressed	Phase 3 Crisis	Phase 4 Emergency	Phase 5 Catastrophe
	HH group is able to meet essential food and non-food needs without engaging in atypical, unsustainable strategies to access food and income, including any reliance on humanitarian assistance.	*Even with any humanitarian assistance:* · *HH group has minimally adequate food consumption but is unable to afford some essential non-food expenditures without engaging in irreversible coping strategies*	*Even with any humanitarian assistance:* · *HH group has food consumption gaps with high or above usual acute malnutrition;* ***OR*** · *HH group is marginally able to meet minimum food needs only with accelerated depletion of livelihood assets that will lead to food consumption gaps.*	*Even with any humanitarian assistance:* · *HH group has large food consumption gaps resulting in very high acute malnutrition and excess mortality;* ***OR*** · *HH group has extreme loss of livelihood assets that will lead to large food consumption gaps in the short term.*	*Even with any humanitarian assistance:* · *HH group has an extreme lack of food and/or other basic needs even with full employment of coping strategies. Starvation, death, and destitution are evident.*

Figure 1 IPC classification: Acute Food insecurity Phases. Reference table for Household Group classification. HH refers to household. Source: FAO (2012)

For Tanzania the last available report is for 2012. As a summary of their assessment MUCHALI reports (2012, iv):

"[…] a total of 29,683 people in 8 assessed Councils fall under […] (IPC) phase 3 and will be experiencing food and nutrition security crisis conditions with very low resilience. A total of 396,920 people in 27 councils fall in IPC phase 2 and will have their food and nutrition conditions stressed. […] Access to food for people in phase 3 and 2 (a total of 526,603 people) is likely to be exhausted from November 2012 to January 2013 and would need immediate intervention to rescue their livelihoods"

Furthermore access to water for human use was identified as chronic problem spread throughout the country, and the availability of access is undermined during dry seasons. Figure 2 shows the IPC status in 2012 for Tanzania.

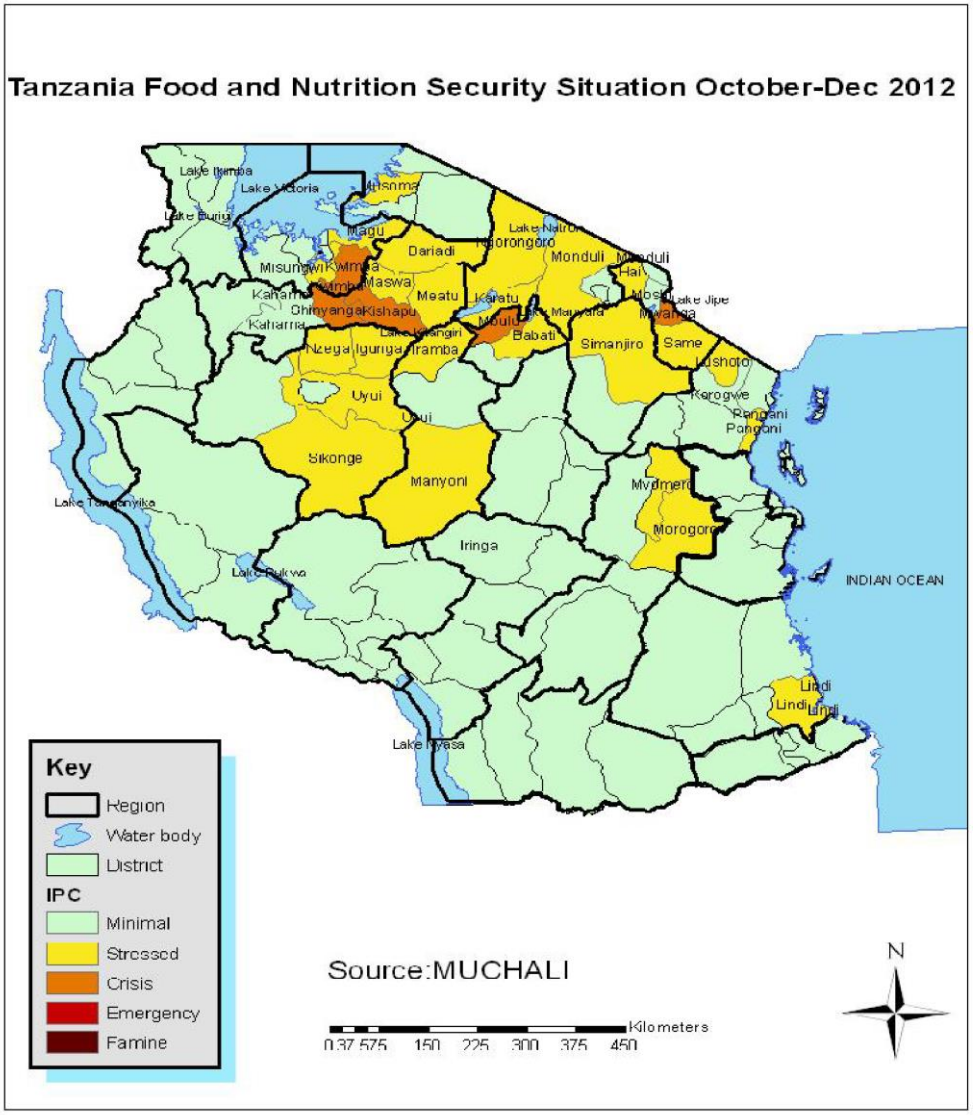

Figure 2 IPC status Tanzania 2012. Source: **MUCHALI (2012)**

Drivers

Food security is weakened by several factors or drivers. The most important drivers affecting food security include pressure on the natural resources land and water,

and climate change (Niang et al. 2014; Boko et al. 2007), increasing energy demand (Haberl et al. 2011), population growth, changing trade patterns and economic systems through trade liberalization and globalization, and governance factors (Lotze-Campen et al. 2010; Riisgaard et al. 2010; Bernstein 2014; van der Ploeg, Jan Douwe 2014).

Regarding the pressure on natural resources, already in 20011 Boko et al. (2007, p. 437)argue that African levels of vulnerability are particularly high; this is similar to the conclusions gathered by Niang et al.(2014, p. 1238). A combination of widespread poverty, institutional failures, limited access to capital, markets, infrastructure and technology, ecosystem degradation, and complex disasters and conflicts create a web of interactions that render vulnerable the African continent. Further, Tanzania, as part of the countries that has semiarid conditions, like in Dodoma region, will likely be severely impaired by the effects of climate change. Equally important are the effects on water scarcity, both for human consumption and for crop production. Mertz et al.(2009) reported that farmers are aware of climate changing conditions. Interestingly, Mertz et al (ibid p. 814) reported that farmers in the focus group did not consider climate an issue of concern. This exemplifies the complexity of relations between food security, changing weather patterns and adaptation strategies. Indeed Mertz et al (ibid p.814) recalls the intricacy of drivers of change and adaptation, mentioning access to farm equipment, inputs of agriculture including seed, and fertilizers, political-economic situation, agricultural policies and market access and development, as relevant drivers together with weather variability.

Changes in land use might be detrimental for food security. Stronger impacts are expected from a change between food production to plantations or monocultures either for biofuel or fiber(Foley 2005, p. 571). Energy demand and the link with food security thus require careful analysis. There is a discussion on the role of biofuel for reduction of greenhouse gases (GHG), however the relations of land use change, between food crops and biofuel, in the price peaks of 2008 is closely related. International markets for biofuel is expected to grow, nevertheless the increased volatility of food international markets will be more severe in the African continent

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(Kornher, Kalkuhl 2013).These is what is known as the “food vs. fuel debate” (Ajanovic 2011; Molony, Smith 2010).Production of biofuel is inherently related to food production. Either the land will be use for one or the other. Haberl et al.(2011, p. 4766) argue that a “cascade utilization” of biomass could be the most sustainable approach. Naik et al.(2010, p. 595) also recognizes the challenges and tradeoffs between biofuel and food crops. Him and colleagues discuss the use of second generation biofuel. The potentials exist, they mentioned, but technologies need still to be further developed. Although, Mohr, Raman(2013, p. 121) warn already that artificial separation between the three pillars of sustainability (social, economic and environmental) might lead to erroneous assumptions of the benefits of second generation biofuel.

Lotze-Campen et al.(2010) designed a model to investigate the tradeoffs between agricultural expansion, intensification and trade. These changes are highly important for food security. In their model demand for bioenergy has been included as an additional driving force for global land-use change. They conclude that high pressure for increased yield increase occurs in Sub Saharan Africa, even without further bioenergy demand. This could be partially overcome if expanded to new non-agricultural areas. Under a scenario of trade increase of agricultural and bioenergy products, the most prospective regions are Sub Saharan and Former Soviet Union states, this is so because the regions have high potential for low cost productivity increases.

There is plenty discussion of the effects of trade liberalization on food security. Antagonistic views for and against liberalization exist. World Bank and Via Campesina are classic examples of those opposed views. The main issues are governance of the value chain and power relations inside the countries and in between trade countries (Moseley et al. 2010).For the scope of this thesis, a good resume of the impacts of trade liberalization is given by FAO et al.(2015). Figure 3 resumes the possible effects of trade liberalization by Food security dimension. In this assessment, interestingly, issues of political economy are missing, for a reference see the work of Baviera, Bello(2009), and Patel, McMichael(2009).

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The possible effects of trade liberalization on dimensions of food security

	Possible positive effects	Possible negative effects
AVAILABILITY	Trade boosts imports and increases both the quantity and variety of food available. Dynamic effects on domestic production: Greater competition from abroad may trigger improvements in productivity through greater investment, R&D, technology spillover.	For net food-exporting countries, higher prices in international markets can divert part of production previously available for domestic consumption to exports, potentially reducing domestic availability of staple foods. For net food-importing countries, domestic producers unable to compete with imports are likely to curtail production, reducing domestic supplies and foregoing important multiplier effects of agricultural activities in rural economies.
ACCESS	For net food-importing countries, food prices typically decrease when border protection is reduced. In the competitive sectors, incomes are likely to increase as the result of greater market access for exports. Input prices are likely to decrease. The macroeconomic benefits of trade openness, such as export growth and the inflow of foreign direct investment, support growth and employment, which in turn boosts incomes.	For net food-exporting countries, the domestic prices of exportable products may increase. Employment and incomes in sensitive, import-competing sectors may decline.
UTILIZATION	A greater variety of available foods may promote more balanced diets and accommodate different preferences and tastes. Food safety and quality may improve if exporters have more advanced national control systems in place or if international standards are applied more rigorously.	Greater reliance on imported foods has been associated with increased consumption of cheaper and more readily available high-calorie/low-nutritional-value foods. Prioritization of commodity exports can divert land and resources from traditional indigenous foods that are often superior from a nutrition point of view.
STABILITY	Imports reduce the seasonal effect on food availability and consumer prices. Imports mitigate local production risks. Global markets are less prone to policy- or weather-related shocks.	For net food-importing countries, relying primarily on global markets for food supplies and open trade policies reduces the policy space to deal with shocks. Net food-importing countries may be vulnerable to changes in trade policy by exporters, such as export bans. Sectors at earlier stages of development may become more susceptible to price shocks and/or import surges.

Figure 3 The possible effects of trade liberalization on food security dimensions. Source: FAO et al.(2015)

Early on Sen (1981) discussed the relevance of access rather than the supply for food security. Access is not only determined by income. In fact there are several others, perhaps more relevant, factors that influence the access to food. Food insecurity hunger and malnutrition are concepts that could be discussed trough the lenses of political economy. In this sense, those concepts are often attributed to the dynamics of inequality and poverty (Bernstein 2014, p. 1034). Those dynamics provide the setting of the possible outcomes of any strategy. Further political stability and willingness are also drivers and constrains of any food security strategy (OXFAM 2010). In terms of access to food, there are discussions on whether, if at all, food insecurity is an outcome of shortage rather than that of wealth distribution(Altieri, Rosset 1999). In this line the interrelated drivers of food security will only benefit from a multidisciplinary perspective.

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2.2. Food Value Chain Approach

Food Value Chain (FVC) is derived from the broader concept of Value chain (VC) (ADB 2012; Dixit 2014). Usually VC is used for the analysis of a single commodity, yet a novel approach was developed by the Trans-SEC project. In their approach the analysis is broader to consider the whole livelihood perspective. However all analytical concepts usually used in a traditional VC analysis are still valid, consequently a brief review of VC is summarized below.

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Although a great deal of literature is directed towards single commodity evaluations, the thesis, and Trans-SEC project, focuses only on local level FVC. Kaplinsky, Morris (2001, p. 23) recognized the value of VC analysis, and highlighted that is not only for global level production systems, they mentioned that it could also be used to understand the dynamics of "intra-country" or regional income distribution.

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Definition

As a concept, VC might be trace down to Porter(1998).In his work he argued that the value chain consists of the series of activities performed by a firm to deliver a valuable product or service. Although Porter's work is the foundation of VC analysis, there are differences compared with "modern" VC analysis (Kaplinsky, Morris 2001, p. 6). Firstly, in modern VC analysis there is a separation in functions performed in the chain, thus drawing attention away from an essentially physical transformation, as it was first conceived by Porter. Secondly what porter considered multi-linked VC is further included by modern VC analysis. This means that activities before considered separated are now included under one single analysis. In brief VC is "simply a framework for trying to understand how the world works" (Mitchell et al. 2009, p. 6).

Accordingly, Kaplinsky, Morris(2001) definition will be used throughout this thesis. Thus VC is defined as "the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use" (ibid

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p.4).This definition is closely similar to that proposed by the World Economic Forum (WEF) for the case of FVC. In their view FVC refers to “the process of growing, producing and marketing food” which “involves a variety of industries and stakeholders along multiple steps, forming the food value chain” (WEF 2009, p. 6).

Three important elements, proposed by Mitchell et al.(2009, p. 8)are worthy to be highlighted at this stage. First the *imperative* of market linkage; “no market = no value chain” (ibid p.8), all activities must be directed to the market. This imperative is challenged by Amanor (2009) for the case of Africa. He argues that the linkage to markets promoted by the World Bank is generating oligopolies in the food industry. The second element is the coordination. All actors within the chain must cooperate to acquire systematic competitiveness. Cooperation should occur even in different countries. The third element is the starting point of analysis. The start point is the internal work of the firm at each stage of the chain. In this regard is important to consider the context under which the firm operates. The so called “business environment” and trade governance thus influence the space for manoeuvre of each actor of the chain.

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Why Value Chain Analysis?

There are mainly three reasons behind the use of FVC analysis. First, the development of trade and high division of labour make the FVC an important tool for analysis. Nowadays firms in different regions or nations specialize in a specific function of the FVC. In order to extract-generate the most value possible over a single chain, functions are shifted to countries where firms are highly specialized or where the conditions, especially labour costs, are favourable. For instance, Alaskan salmon is caught, frozen, shipped, defrosted in Asia, filleted and boned, refrozen, and shipped back to the USA (Greenberg 2014). This procedures requires coordination among the links and creates “systemic competitiveness” that allow for lean production. In this sense the use of the FVC framework helps to analyze the whole system as a single unit overcoming intersectoral barriers of analysis (Reif et al. 2015).

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A second reason for the use of FVC analysis is strategic in nature. FVC analysis strategically highlights the advantages and disadvantages over specialization in a single function. Services is rewarded higher than production, thus specialization on this functions will bring more benefits. In order to gain more benefits the firms establish certain links in regions where favorable conditions exits. Consequently certain regions may develop certain functions more than others. Exchange rates, trade policies, technology access, gov. policies among others will create a market for the establishment of firms. As a result the use of FVC analysis ensures that the whole sequence of links from inputs to product to final consumer is analyzed.

Finally FVC analysis is useful for distributional analysis. Trough in depth study of income dynamics, policies can be implemented to intervene the behavior and outcomes of actors along the chain. This type of analysis is even more relevant with the increasing degree of globalization. Further, it is also useful for analysis of region or country level. The systemic perspective of the analysis helps to elucidate the "why" and "how" of outcomes at every link of the chain. Thus VC could be both as a positive and normative analysis. Positive because it helps to understand the reasons behind outcomes; and normative because it is possible to design appropriate interventions.

Governance is central in the FVC analysis because of market access, transfer of technologies and capabilities, distribution of rents and government strategic action (Humphrey, Schmitz 2001, p. 20). The participation of actors in a "well" coordinated FVC may have benefits that otherwise will be absent for non participants. Actors integrated in the chain gain preferential access to markets. Through their vertical connection actors along the chain may benefit from the closer relation trough contacts, logistics, costumer portfolios and potential market size.

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Retaining competitive advantage encourages transfer of technologies and capabilities. Quality standards, scheduling, production volumes and processes, requires standardization of production. Thus there is an incentive for coordination that usually requires transfer of technologies, know-how, techniques and capacity

building along the chain. However, there is a risk, mostly present with commodity producers or early stages of the chain, of a specialization trap (Schmitz, Knorringa 1999). Commodity producer may specialize in a function that on the long run may not be able to generate sufficient or sustainable returns, or that is vulnerable to market volatility, thus jeopardizing their role in the chain because of increase competition.

Upgrading

The constant search for the competitive edge pushes firms to innovate. In this competitive environment firms must innovate relatively faster to retain their advantage. This process is referred to as upgrading (Kaplinsky, Morris 2001, p. 37). Further,Stamm(2004, p. 25) defines upgrading "as the process that enables a firm to take on more value-intensive functions in the chain, make itself harder to replace, and thus appropriate a larger share of the generated profits".In the same line,Gereffi, Fernandez-Stark(2011, p. 12) defined upgrading as "firms, countries or regions moving to higher value activities in GVCs in order to increase the benefits (e.g. security, profits, value-added, capabilities) from participating in global production". Additionally, Riisgaard et al.(2010, p. 198)consider upgrading as "something that happens to a specific actor (an economic group, organization or individual) inside the chain; it directly improves the performance or position of this actor, thereby increasing rewards and/or reducing the exposure to risk". Thus is possible to say that upgrading is a process by which actors in the chain actively search for better deals.

Governance and Upgrading are concepts related to the view point one uses in the analysis of the VC. From the top down view the key concept is governance; whereas for the bottom up view the key concept is upgrading (Gereffi, Fernandez-Stark 2011). This is related to power dynamics. For example a (single) farmer may not be able to exercise coercion or accountability on the links above him. Thus governance, although relevant, is relatively out of reach. On the other hand, upgrading becomes the tool of choice for the analysis and strategy development when the unit of analysis is the farmer.

Upgrading may arise from two developments. First it could arise from development of competences. This type refers to the ability of the firm to concentrate in those competences that increment the value addition that the firm does, thus providing an advantage from the competitors. Second, upgrading also arises from development of dynamic capabilities. Those capabilities arise from internal processes that encourage innovative learning; the position of the firm, in the sense of its access to innovation outside of the chain; and third, the capabilities are path dependent.

There are four trajectories that firms-farmers can adopt to pursue upgrading(Kaplinsky, Morris 2001).First process upgrading. In this case a drive for increasing efficient use of resources/inputs and technological updates are behind this trajectory. Second is product upgrading. Companies can move to products where the expected returns are higher. Third is functional upgrading. Firms may assume other functions, or avoid (outsource) in order to increase the efficiency and add more value to the product. Fourth is chain or inter-sectoral upgrading. This is related to moving from one chain to other with higher returns, where the technological, capital and know how are not so dissimilar.

In the case of poverty alleviation Riisgaard et al.(2010) identified seven different UPS for small producers and categorized in three types. Generally the categorization coincides with that of Kaplinsky, Morris(2001). The categorization is: improved process, product or volume; change or adding functions; and improved value chain coordination. Worth to mention is the acknowledging of UPS interaction. The following diagram XX is a visualization of the context of UPS and their interactions. As mentioned above UPS may involve different types of actions at different links of the chain. For example upgrading to a new product line, may require new processes, coordination with upstream links for securing sales, new functions may develop for some actors, like processing of the new product. All of these actions happen under a context of institutions and economic environment.

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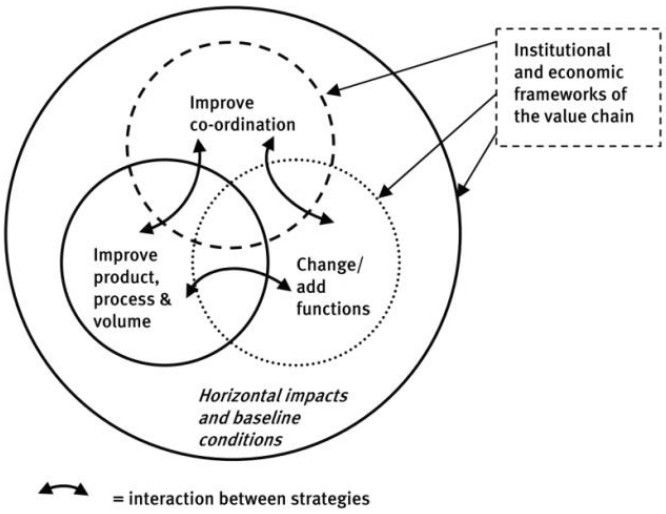

Figure 4 Types of upgrading strategies for small producers. Source: Riisgaard et al (2010, p. 201)

Upgrading is, then, critical for distributional outcomes. Thus, policies, institutions, company strategies, technologies, and worker skills are associated with upgrading outcomes (Gereffi, Fernandez-Stark 2011, p. 12). Upgrading should consider not only power imbalances, but the full range of livelihood opportunities and networks available for actors (Riisgaard et al. 2010, p. 203). Then, an important remark is the "upgrading path". Evidence suggest that there is a hierarchy of upgrading (Kaplinsky, Morris 2001, p. 39), but the questions remains as to whether this hierarchy is "set on stone". Capacities, knowhow and technologies do not follow a traditional linear development. Then it could be argued that"leap frog"could be achieved if proper decisions are made. In this thesis upgrading of the chain occurs at every link. From Natural resources to Consumer there are upgrading strategies that were implemented. In the chapter XX a description of all strategies will be presented.

There are typical upgrading strategies in a FVC analysis. First those related to management of natural resources. This type is related with the efficient and sustainable use of natural resources. Second upgrading related to production. In this case water harvesting, improved seeds and production techniques are

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common. This is the common approach of productivity improvement. Third upgrading related to processing. In developing countries postharvest losses are a widespread problem. Strategies related to this problem help to upgrade the chain. Four upgrading of marketing capabilities, in this case product development is a typical example. ADB(2012) considers this strategy with high potential. The last upgrading strategy is the consumer link. In this case the consumer may be the farmer too. That is why, for example, strategies that increment the nutritional value of food produced, might be beneficial for upgrading.

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The link between value chain and food security

As discussed above food security is multidimensional phenomenon. That is, strategies to overcome it can be developed under different theoretical stances. In this sense there is plenty of literature discussing the link between FVC and poverty reduction (KIT et al. 2006). Poverty and food security are highly related; yet in this thesis, strategies to deal with food security are developed and implemented using the FVC approach. Dixit(2014)argues that the AVC/FVC perspective matches, interestingly, with that of the United Nations High Level Task Force (HLTF) in its Comprehensive Framework of Action (UCFA) in deal with global food security challenges. In this section the main conceptual bridges linking these two concepts.

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The use of FVC to deal with the agricultural sector enables the analysis of the whole range of interrelated actors that interact in the food system. Further following the definition of food security presented here, a FVC could be designed such that considers every definitional component (Dixit 2014, p. 972). The availability dimension of food security, as related to agricultural productivity (or trade), is comprehensively considered under the FVC. For example, the relations between input suppliers and farmers. A series of consequences of this relation could be analyzed, distributional effects, productivity, yields are all related to this *link*. The use of FVC thus provides a departing point for analysis of this dimension.

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Access to food is a big driver for food insecurity, especially for the rural wage laborers. Low income for laborers, as well as for farmers, limits the market access

to food. A VC analysis could be used to develop strategies that for example upgrade the production of farmers by developing new products or could also identify where and why the value produced already is insufficient to provide access to food for both groups.

Food utilization dimension may also be considered under a VC analysis. Food utilization considers the consumption stage of the products. The nutritional and consumption process of food is the main focus of this dimension. In a VC analysis one of the links is the consumer. Thus the food quality and nutritional values are analyzed. A situation where the requirements from the market and the retailers, puts in jeopardy the participation of farmers in the supply, and thus reducing food security for farmers (and availability in the market) could be easily analyzed with the VC framework.

Gomez et al.(2011 p.1154) defined FVC as the "activities required to bring farm products to consumers, including agricultural production, processing, storage, marketing, distribution, and consumption" It consists of five links or components (Figure 5): natural resources, food production, processing, markets and consumption (Graef et al. 2014, p. 10); waste management could be considered the feedback loop check.

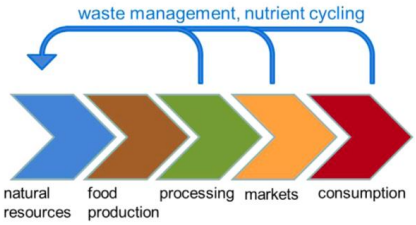

Figure 5 Food value chain components. Source: Graef et al.(2014, p.10)

A FVC may also help to distinguish alternative strategies for food security. A comprehensive analysis of the FVC may, for example, inform diversification possibilities existing in the chain. While mapping the flow of value and identifying bottle necks, new businesses or policy recommendations could be formulated. For

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example a FVC analysis may identify that the income of farmers is insufficient because their produce is not reaching the market at the quality required. The quality may be improved if storage services are developed. This new venture, diversify the local economy providing new employment and increasing the income of farmers by ensuring a quality increase. Consequently, food availability at local level trough increased income and diversified income sources are increased. A FVC framework is not a "panacea" for agricultural sector (Dixit 2014, p. 980) or for food security. Although it provides sound standing ground for analytical interpretations, strategy development and policy action, that in turn, might help to alleviate some of the food security problems.

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2.3. UPS Impact Assessment

The process of innovation creates upgrading strategies (UPS). The effect of those UPS is called impact, and their assessment, Impact Assessment (IA). In this section I discuss the concept of IA. The methodology used by Trans-SEC to assess the impact of UPS is presented in section 4.1

Classification of IA

Impact can be classified based on its effect. Following Kelley et al.(2008), Rogers(1995) and Airaghi et al.(1999), impact effects can be desirable (positive) or undesirable (negative); direct or indirect; primary or secondary; anticipated or unanticipated; and short-term, medium-term or long-term. Consequently projects should be aware of all effects of innovations. For example an innovation in environmental management may have positive and negative effects, and also the effects might be short-term and long term. This time lag between innovations/UPS and their tangible effect have created frustration among farmers in such cases for example as "seed thresher" and "improved storage bags" (see Table 17).

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Additionally impacts effects may be classified on type. The most usual are scientific, political, institutional, productive environmental, economic and social(Barrientos-Fuentes, Berg 2013). Generally environmental, economic and social are considered the "final" goal-impact of sustainable development. In this thesis the impact of UPS will be classified under the sustainable development criteria, as well in the food

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security criteria (FSC) purposely developed to capture the local context (see section 4.1, Table 2, Schindler et al., submitted for publication p.9). The types of effects are interacting. For example a purely environmental innovation, say water harvesting, may lead to a social impact like food security. The FSC developed for Trans-SEC aims to capture these interactions and tradeoffs.

The objectives of IA

The “average” rationale behind evaluations was and still is purely economic driven. The purpose is to know if the money spent was, first, allocated as predicted, and second, to know if the expected results were achieved; in other words, if the money spent produced the outcomes envisioned. Proving the rate of adoption was the main focus. However, nowadays there are new tendencies in evaluation of impacts(Barrientos-Fuentes, Berg 2013). The evaluation might be used for analysis of unexpected effects of innovation and externalities, learning tool for researchers and research institutions, identification of diffusion defects, tool for strategic out-scaling and up-scaling of innovations, as a management tool, prioritize the best investments, and promote and manage new and ongoing research.

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IA is essential for providing evidence regarding extent and effectiveness of innovations. Thus they serve as an instrument for achieving poverty alleviation, food security and other development goals. Nonetheless, traditional evaluations are too rigid. The "logical" approach of needs-action-reaction, might lead to short sided evaluations. For example indicators generated by this approach, like number of seedlings planted, farmers participating in the trainings etc, do not generate a fully reliable picture of implementation, adoption, or rate of success. Development projects are bounded by strict time constrain and budgets, thus, is understandable, that indicators of this sort are evaluated. These evaluations serve the purpose of continuing or not the funding. Thus, ensure that money was well spent. Nevertheless further steps towards ensuring the success of projects should be taken.

Ensuring project success requires that IA takes a holistic approach. Avoiding top down thinking is a prominent step. On the early days of transfer of innovation, there was only a one-direction flow of information. Scientist will develop farmers will

adopt. Nowadays understanding farmers' perspectives, constraints, and reasoning is crucial (Rogers 1995; LILJA, DIXON 2008). Further, context matters. Scoones(1998) pointed at the combination of capitals and endowments; van der Ploeg, Jan Douwe(2014) adds the analysis of political economy of agriculture as an important determinant of productivity growth. Moreover, acknowledging the long term effects of innovations is important (Rogers 1995). In the same line Schindler et al. (2015, p1054) argued that only approaches which "(a) integrate equally all three sustainability dimensions, (b) respect their interrelations, (c) involve stakeholders actively at every step of the assessment process, and (d) also focus on exchange and learning can be considered as a complete or holistic method of sustainability impact assessment".

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Methods of IA

There are many methods of impact assessment. The relevance of each is determined case by case and it is dependent on availability of resources and time. The methods used in agriculture related activities are, generally, economic and environmental. Barrientos-Fuentes, Berg(2013) made a review of 28 impact assessment of innovations in agriculture related activities, and concluded that the majority used economic surplus approach (for consumers and producers) and economic surplus approach (for consumers and producers). In these cases the rate of return (ROR) was used. Nonetheless most of the studies analyzed used a multicriteria approach and mix methods.

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The analysis of impacts only by economic variables reduces the power of the assessment. There are of course several other types of impact assessment that go beyond the socio economic effects. The classic example is the Sustainable livelihood framework (Scoones 1998). Other analysis are Life Cycle Assessment (LCA), Strategic Environmental Assessment (SEA), Environmental Impact Assessment (EIA), Environmental Risk Assessment (ERA), Cost-Benefit Analysis (CBA), Material Flow Analysis (MFA), and Ecological Footprint (Finnveden et al. 2009, p. 1). Moreover, a refinement of analysis of interactions of impacts is the Sustainability Impact Assessment (SIA). This approach explores the combined economic, environmental and social impacts of innovations, policies, programs,

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strategies and action plans (OECD 2010). Figure 6 gives a brief overview of types, techniques and methods of impact assessment in agriculture, however an integrated assessment is missing from the review of Barrientos-Fuentes, Berg (2013).

Type	Technique	Method	
Institutional and political impact	• Simple comparison • Trend analysis	• Survey • Monitoring of selected variables	
Productive impact	• Simple comparison • Target versus actual	Effectiveness analysis	• Logical Framework Analysis
Environmental impact	Various (need biophysical information)	Environmental impact assessment	• On-site market impacts • On-site non-market impacts • Off-site market impacts • Off-site non-market impacts
		• Risk assessment (RA) • Environmental risk mapping • Life cycle analysis • Multi-agent system • Linear programming • Agro-environmental indicators • SimaPro: ReCiPe, BEES, Eco-indicator 99, Eco-indicator 95,CML 92, CML 2 (2000), EDIP/UMIP, EPS 2000, Ecopoints 97, Impact 2002+, TRAC, EPD method, Cumulative Energy Demand, IPCC Greenhouse gas emissions	
	Qualitative and quantitative	Qualitative assessment	
Economic impact	Various	Efficiency Analysis (ROR)	**Ex-ante:** • Financial Analysis (FA) • Cost-effectiveness analysis (CEA) • Break-even analysis (BEA) • Business case calculations (BCC) • Benefit-cost analysis (CBA) • Multi-criteria analysis (MCA) • Scoring models • Simulation models • Mathematical programming models **Ex-post:** • Econometric approach marginal rate of return (MRR) • Surplus approach or Index Number Approach **Average Rate of Return (ARR):** • Benefit-cost approach **Index number approach using elasticities:** • Linear functions with parallel shifts • Linear functions with non-parallel shifts • Non-linear functions with parallel shifts • Non-linear functions with non-parallel shifts • Unit cost saving approach • Others
Social impact	Comparison over the time	• Socio-economic survey • Adoption survey • Monitoring of selected variable • Propensity Score Matching (PSM)	

Figure 6 Types, techniques and methods of impact assessment in agriculture. Source: Barrientos-Fuentes, Berg(2013)

Regarding sustainability impact assessment (SIA) Schindler et al. (2015) made a review of methods of sustainability impact for farming interventions in order to verify if the requirements of sustainability impact assessment theory are fulfilled. Their

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review is focused on ex-ante interventions, however is relevant for this thesis since it highlights and compares FoPIA with other nine methods.

There are ten methods cited by Schindler et al. (2015) which are Ex ante poverty impact assessment (PIA), Framework for participatory impact assessment (FoPIA), Participatory impact pathways analysis (PIPA), DESIRE-Decision Support Systems (DESIRE-DSS), MESMIS framework (Spanish acronym for Indicator-Based Sustainability Assessment Framework), ScalA, Nutrient use in animal and cropping systems–efficiencies and scales framework (NUANCES), Response-inducing sustainability evaluation (RISE) and finally Trade-off analysis model for multi-dimensional impact assessment (TOA-MD). The methods range from participative frameworks (FoPIA, PIPA, MESMIS, DESIRE-DSS) over to quantitative modeling approaches (NUANCES, Farm-Images, TOA-MD) to indicator/interview-based approaches (PIA, ScalA, RISE).

Their review highlighted that the minority of methods follow the holistic understanding of sustainability impact assessment theory (Schindler et al. 2015, p.1054). The methods vary regarding the their initial point of observation; intervention aims (themes); the majority uses mix methods i.e., of qualitative as well as of quantitative analysis practices; level of application and spatial scale; end user of the results; and time horizons.

Moreover their review highlighted issues like 1) the equal consideration of the three dimensions of sustainability varies among the methods, for example FoPIA restricts the number of indicators to nine to link regional sustainability. 2) none of the methods considers the institutional dimension. The rules and regulations where the interventions are set determine in great account the outcomes, thus the inclusion of this dimension is primordial. 3) stakeholder involvement and learning varies among methods, for example only DESIRE-DSS, FoPIA, and PIPA particularly focus on the learning process throughout the assessment process.

3. Case study

3.1. Trans-Sec Project

Trans-SEC: Innovating Strategies to safeguard Food Security using Technology and Knowledge Transfer: A people-centred Approach is an international research project with stakeholders, mainly, in Tanzania and Germany. It involves research centers, universities, government bodies, private sector, and local actors. Trans-SEC framework focuses on rural FVC and considers both subsistence and surplus farming for local and regional markets (Graef et al. 2014).

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The objective of the project is to improve food security for the most-vulnerable rural poor population of Tanzania. Trans-SEC uses the FVC analysis as analytical framework. Consequently it is designed to identify upgrading strategies along local and regional FVC. Once identified, tested and adjusted, a second aim is to disseminate those successful strategies.

The treatment of the FVC in Trans-SEC is novel. Usually a FVC analysis focuses on one single product, service or commodity, coffee for example. On the contrary, Trans-SEC uses the FVC framework in a systemic way. It considers the FVC as part of the food system. The food system, for the case of Tanzania is comprised by: "(a) the use of local resources (soil, water, nutrients, energy, and labour), (b) the use of production inputs (technical devices, fertilizers, animal feed, and seeds), (c) techniques for ensuring safety and quality of food in production, processing and storage, (d) specific consumption and dietary patterns, (e) site-adapted cropping including agro-forestry elements, (f) animal husbandry, (g) local and/or regional market access and prices, and (h) region-specific cultural, political and social environments and FVC governance" (Graef et al. 2014, p. 10). Thus, in this sense all activities involved from natural resources to consumption of the product, including waste management, could be analyzed by the links of the chain in a FVC analysis. This, approach serve the purpose of focusing on the improvement of local livelihoods connected to food production.

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The selection of CSS for the Trans-SEC was purposive. The CSS were selected so to represent the majority of farming types in Tanzania. Two regions where selected with different farming types and weather patterns; from each region two CSS were selected, Idifu and Ilolo for Dodoma region, and Ilakala and Changarawe for Morogoro region. The main criteria for selection was: “(a) similar climates; (b) differing market access; (c) differing rained cropping systems, possibly integrating livestock; and (d) village sizes with 800–1500 households. If possible, [...] farmer association MVIWATA is active and no other large R&D projects intervene [...] the number of stunted children below 5 years as an indicator for food insecurity, available logistics, infrastructure and facilities, differing wards, soil types, and population density. Each CSS consists of at least one local market place and the surrounding 2–3sub-villages and has at least partial access to markets for cash crops.” (Graef et al. 2014, p. 10).The selection criterion allows scaling and comparability, as well as allows for analysis of every link of the chain.

The project is at half of its project duration, year three of five (Figure 7). Thus is important to consider that impacts on *a*gricultural research, require very long-cycle activities; therefore, the measurement of actual impacts necessarily might occur many years after the initial intervention.For example, LILJA, DIXON(2008, p. 9) reported a period of 5-10 years for full adoption and impact; thus this thesis may only observe a portion of the ultimate benefits.

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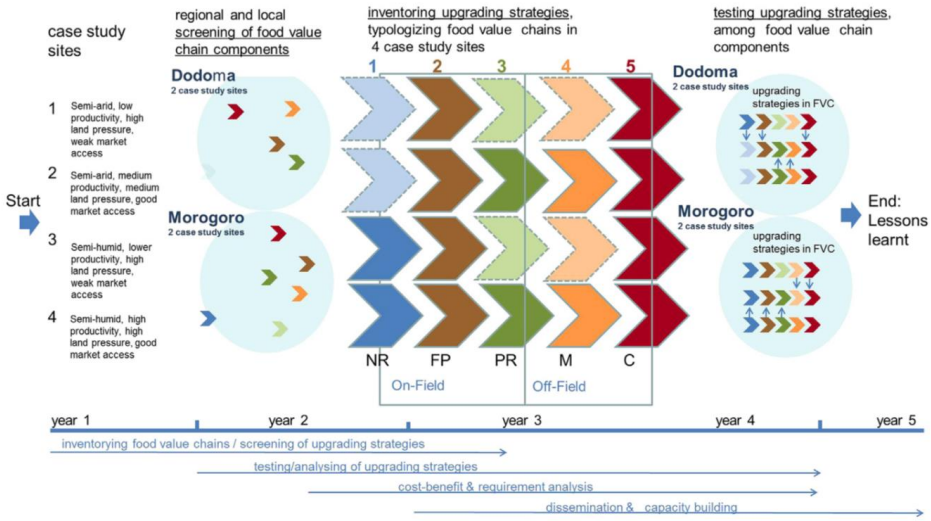

Figure 7 Trans-SEC analytical framework Food value chain and temporal succession of research tasks (NR – natural resources, FP – food production, P – processing, M – markets and institutions, C – consumption; more description given in text). Source: Graef et al. (2014, p. 12)

Upgrading Strategies Status

Upgrading strategies is at the core of Trans-SEC. The last report available of UPS implementation status (August/September 2015) reported different status among the CSS. Table 17 presents the selected UPS and summarizes the related information. Not all UPS where selected for every village.

The analysis in this thesis is midterm, thus UPS are still been adjusted, and there are still challenges to overcome. For example, there are some groups that were frustrated with the speed of implementation and the implicated costs. Moreover there were some weather related challenges, which influenced the impact score and perceptions.

Farmer's reasoning behind score assessments is referred as "impact arguments". Impact arguments were collected by the Trans-SEC moderators, as part of the field notes of the focus groups.

In this sense, implementation status and impact arguments will be important to understand impact scores.

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Upgrading Strategies Overview

1-Rainwater harvesting (RWH/MF), refers to the process of collecting, concentrating and storing various forms of runoff water. The purpose of this strategy is to concentrate water to increase its efficient use. It is particularly beneficial in semi arid regions. Hatibu et al.(1999) reported increased yields in Morogoro region.

2.-Tree planting (Agroforestry). Agroforestry is the “integration of trees with annual crop cultivation, livestock production and other farm activities” (Dawson et al. 2013, p. 1). Agroforestry is recognized as a tool to achieve the millennium development goals, and is especially important in Africa for food security (Garrity 2004).

3. By-product for bioenergy (Biochar) for soil improvement Biochar is a charcoal-similar material, produced by thermal decomposition of organic material at high temperatures and without oxygen. Is “produced with the intent to be applied to soil as a means of improving soil productivity, carbon storage, or filtration of percolating soil water” (Lehmann, Joseph, p. 1).

4. Poultry. The integration of small livestock has the opportunity to increase farmer’s availability of food. Additionally it might be a diversification strategy, and a safety net for poor households. This strategy was only selected in one CSS.

5. Sunflower oil pressing. This UPS is related to the processing and market link. It represents a new venture enterprise for the CSS. Sunflower oil is a commodity that could diversified the portfolio of livelihoods for the CSS. Moreover the sub products of oil processing (e.g. seed cake) could be used as livestock feed. Processing of oil requires considerable quantity of seed, thus encourages farmers cooperation. Additionally cooperation and farmers organizations are required for to acquire the machinery.

6. Storage Bags. Farmers in this area had problems with storage of produce. After harvest losses is a wide spread problem in developing countries. Small scale storage like storage bags might be appropriate technologies. This strategy allows farmers to store grains for consumption and prevent losses. Importantly this strategy also gives farmers bargaining power, because they don’t need to sell immediately after harvest and can “wait” until prices increase.

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7. Improved stoves. There are many benefits related to improved stoves. Open fire cooking is related with pulmonary diseases. This UPS might be able to address this problem. The quantity of wood that these stoves require, when good management practices are maintained, is lower than the traditional three rock; consequently reducing the pressure on natural resources. Additionally, the efficient use of wood of these stoves reduces the work load of collecting wood, that in many cases in developing countries is kids and women work.

9. Kitchen garden and nutrition education. Food insecurity is not only an outcome of availability. Food needs to be diversified and process in a way that conserves or enhances its nutritional value. Cultural habits might lead to micronutrient deficiencies. Therefore education, awareness and change of behavior could help alleviate some of the risk associated to nutrition deficiencies(Hawkes 2013). This UPS encourages the establishment of kitchen garden and provided nutrition awareness in the CSS.

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3.2. Tanzania Case Study

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This section provides a description of the four CSS, which were selected by the Trans-SEC project. This information will define the general context in which the UPS were implemented.

Tanzania is predominantly an agricultural economy. This sector employs more than 75% of the work force, accounts for 24.1% of GDP and 30% of export earnings(URT 2013, p. 2). There have been some improvements; however, there is still widespread poverty. Close to half of the population (17 million people) live below the poverty line of US$0.65 per day (URT, p. 4). Food crops represent about 65 % of agricultural GDP, compared to 10% for cash crops (URT 2013, p. 2). Maize production is the most important crop accounting for 20% of agricultural GDP. Food and cash crops is the main source of income for the rural population, accounts for about 70% (ibid p.2)

Generally the rural areas have bigger households compared with urban populations. The average age of household head is slightly higher but significant. Rural

population education is almost to the level of primary school. Additionally access to general services is significantly lower for the rural population. Table 1 describe the general household characteristics. It is based on "data collected by the Tanzania National Bureau of Statistics (NBS) from October 2008 to October 2009 as part of the first wave of the Tanzania National Panel Survey (NPS), a nationally representative living standards survey" (Covarrubias et al. 2012, p. 10).

	Urban	Rural	T-test	*N*
Household size	4.42	5.43	***	*3255*
# Household members of working age	2.62	2.52		*3255*
Household head characteristics				
Age	42.28	47.22	***	*3255*
Female	0.28	0.24	**	*3255*
Single	0.38	0.25	***	*3255*
Years of schooling	7.02	4.43	***	*3255*
Highest years of schooling in household	8.31	5.83	***	*3255*
Dwelling characteristics				
Flush toilet	0.15	0.03	***	*3255*
Electricity	0.43	0.03	***	*3255*
Running water	0.15	0.01	***	*3255*
Public garbage collection	0.29	0.00	***	*3255*
Kilometers from dwelling to:				
Nearest government primary school	0.29	0.15	***	*3255*
Nearest private primary school	4.33	23.44	***	*1040*
Agricultural plot	7.02	0.98	***	*2287*
Kilometers from plot to:				
Nearest market	5.96	6.85	***	*2287*
Nearest road	1.57	1.13	***	2287

*Note: Asterisks denote significant differences based on t-tests across urban and rural as follows: * significant at 10%; ** significant at 5%; *** significant at 1%.*

Table 1 Tanzanian household characteristics. Source: Covarrubias et al. (2012, p. 12)

3.3. Case study sites

Dodoma-Idifu and Ilolo

Dodoma region is situated in the in the middle of Tanzania, between latitude 40 and 70 (degrees) South Latitude and 350 – 370 (degrees) East Longitude. Borders with Morogoro region (also part of Trans-SEC project). Predominantly a plateau, it raises to 2,000 meters above sea level in the highlands North of Kondoa.

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The climate is that characteristic of the savanna (semi-arid), with dry periods of drought from April to early December, and a short rainy season. It has this characteristic due to its position relative to the mountains of Domoda on the east. It receives an average rainfall of is 570mm in Dodoma town, although it tend to be slightly higher in the agricultural districts of Mpwapwa and Kondoa. December and March receive 85% of this falls (URT 2006, p. 1). The erratic pattern of rain in January makes sowing problematic for the farmers in the region.

Dodoma is almost entirely dependent in agriculture and related activities practiced at subsistence levels. It produces food crops like sorghum, maize, paddy, beans, bulrush millet, groundnuts and finger millet. Additionally cash crops like sunflower and simsim.

USAID(2008, p. 31) reported two main livelihood zones for Dodoma. Both are similar in characteristics, although one has the distinction of production of grapes, which are used for consumption and production of wine. In both regions food crops are composed by sorghum, bulrush millet and maize. Livestock production is also practiced particularly by better off households. Cattle, shoats, and poultry are sale to traders at the village level. Additionally, these better-off households are involved in the production of cash crops, like sesame, groundnuts, and sunflower, which are both for local and regional markets in Dodoma or Dar es Salaam. Poorer Households on the contrary may not be able to sustain themselves with their own production. Thus they will rely on food purchases to supplement their needs. To gain income for this purpose they hire their labour in local areas but some migrate for seasonal work. Moreover some households in this are produce charcoal as a complement of their livelihood.

Rain is the main risk for the livelihood in this region. Livestock producers depend on rain event for pastures. Cash crops also need regular rain patterns for establishment and development. This risk is the main impediment for food security and ultimately for livelihood resilience.

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Morogoro-Ilakala and Changarawe

Morogoro borders to the west to Dodoma and Iringa. It is situated at latitude 5 degrees and 10 degrees to the South of the Equator and longitude 35 degrees and 35 degrees to the East. After Arusha and Tabora regions, it is the third largest region in Tanzania. In most parts of the region there is an average temperature of 25 degrees. It is considered as primarily as semi-humid climate. This region receives an annual precipitation of 600mm per year, but it experiences exceptional droughts in some districts (URT 1997, p. 27).

The region is composed by three agricultural zones (URT 1997, p. 27). The zones are categorized by the relative altitude. In the lowlands and river valleys, the crops produced are paddy rice, maize, sugarcane, bananas, cocoyams, cassava and sweet potatoes; and the livestock is primary poultry. The second zone is the plateau, from 300- 600m. In this zone crops like maize, sorghum, sweet potatoes, cotton, sunflower, simsim, citrus, paddy, cassava and banana dominate. Livestock is also produced here, in this case cattle, sheep and chicken. The third zone is the highlands, above 600m. This zone is characterized by maize, vegetables, fruits, coffee, cocoa and citrus. The average livestock raised is poultry, pigs, goats and sheep.

Relative to its size, Morogoro has diverse climatic conditions and livelihood opportunities. USAID (2008, p.8) reports eleven livelihood zones for Morogoro: 1)Ruaha Riverine Maize, Onion, Tomato, and Paddy Lowlands. 2) Chalinze-Tunuguo Maize, Cattle, and Cassava. 3) Kilombero-Mtibwa Paddy, Maize, and Sugar Employment. 4) Kilombero-Ulanga-Lusewa Paddy, Maize, and Cassava. 5) Kilosa-Mvomero Maize and Paddy Lowlands. 6) Matombo-Kuyuni Spice, Maize, and Banana. 7) Morogoro Highland Maize and Vegetable. 8) Maskat-Kimbet Maize and Beans Highlands. 9) Handeni-Bagamoyo Maize, Cassava, and Fruit Midlands. 10)Kiteto-Kongwa-Mpwapwa-Mvomero Maize, Sorghum, and Pigeon Pea. 11)Mtwara-Lindi-Pwani Riverine. However number 3 and 4 are the biggest in area.

Zone 3. In this zone the production of maize, cassava, and rice it's consumed at household level, surplus is sold for additional income. Cash crops are comprised by

rice, maize, and bananas. This is traded to middlemen who take it to other regional trading centers. Poorer households also rely on wage labor and seasonal migration. Moreover, poorer households produce products from forest like charcoal and timber to supplement their livelihoods. Better-off households besides cash crops, that it's their main source of income, raise livestock for local markets.

Reliance on food and cash crops to satisfied their food needs make this zone susceptible to climate risk. Ulanga and Lusewa districts had received food aid in the past. Additionally there are reports of conflicts over land and resources in some of the western wards in Kilombero district.

Zone 4 is mainly as lowlands. Households in this zone rely heavily on food production for market and self consumption to meet their needs. Sesame, maize, rice, sorghum are sold in this zone, later the produce is transported to Dar es Salaam markets. Livestock production is second in income generation. Better-off households sell cattle and goats, while poorer households sell mostly chickens and goats. Poorer households sell their labour in farms and in surrounding towns. In the past there were reports of conflict with pastoralist.

4. Methods

As part of the Trans-SEC project, two missions (2014, 2015) were undertaken to conduct a series of stakeholder focus group discussions to assess alternative food securing UPS towards regional food security. For this purpose, a number of upgrading strategies (UPS) was developed as part of Trans-SEC and subject to two assessment rounds: first, an ex-ante UPS assessment(before implementation) in 2014, and second, an ex-post assessment (during/after implementation) in 2015.

In this section, I first describe the main methodology used for these assessments, namely "Framework for Participatory Impact Assessment (FoPIA) (section 4.1). And secondly, I also introduce the analytical procedure which has been used to compare the results between the ex-ante assessment in 2014 (FoPIA 1), and the ex-post assessments in 2015 (FoPIA2) In order to answer the research questions, two

consecutive assessments were made. First an analysis of impact scores comparing FoPIA 1 vs. FoPIA 2 evaluations (section 4.2). After, the second section analysis aims to discover underlying household characteristics which could be possible reasons that might influence impact scores (section 4.3).

4.1. Framework of Participatory Impact Assessment (FoPIA)

FoPIA stands for Framework of Participatory Impact Assessment. It was originally developed by Morris et al. (2011) for land use policy impact assessment in the European context. The purpose of FoPIA is to assess, in a structured methodological procedure, criteria previously developed trough a participatory approach. In this way contextually adapted approaches and tools are developed, thus enabling sound and informed decision-making (König et al. 2010).

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Originally, the focus of the FoPIA was sustainability impact assessment of policy induced land use changes towards sustainable development for the European context (Helming et al 2011). Later on König et al. (2010; 2012; 2013) adapted the framework to assess land use related policies in the context of developing and transition countries, in issues such as impact of land use policy in Indonesia, and soil and water conservation assessment scenarios in Tunisia. Nowadays Schindler et al. (2016) further developed FoPIA towards food value chain (FVC) assessment; this last work is the most related analysis to this thesis, although they only analyzed FoPIA 1 impact assessment scores. The development of FoPIA addressed the need of research strategies that understand the fundamental interactions between nature and society (König et al. 2012, p. 154).

The FoPIA framework constitutes the core of the participatory evaluation in Trans-SEC. FoPIA was used to develop the food security criteria, by which the UPS will be evaluated (Schindler et al., submitted for publication); used to select UPS (Graef et al. 2014; Graef et al. 2015b; Graef et al. 2015a); and used to conduct the local focus group discussions where the selected UPS where evaluated (Schindler et al. 2016).

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The structure of FoPIA as was applied in Trans-SEC, is depicted in Figure 8. The procedure is as follow:

Phase 1: analysis of the geographical and food security contexts

In this phase the focus is to define the food security context and to derive locally relevant food security criteria (FSC) trough a participatory process. Focus group discussions of 15 to 19 participants were organized to define their understanding of food security and their challenges at the local level (step 1); later they translated those challenges in to locally relevant criteria (step 2) (Schindler et al., submitted for publication). The farmer's definition and criteria is presented in Table 2. The selection of participants was purposive, focusing on:

> "(I) their competence, experience and knowledge regarding the food value chain component and related UPS; (II) their knowledge on the agricultural practices in the village; (III) the representation of different sub-villages; (IV) a mixed representation of gender (app. 50% women and 50% men); (V) a representation of different age groups (young: age 15–25 years, adults, elderly people: age = above 60 years); (VI) the economic status of the household (poor, moderate, better off); and (VII) that "stakeholder participants should not be too dominant due to their hierarchical position" (Schindler et al. 2016, p. 54).

Phase 2: impact assessment of local food security upgrading strategies

In this phase the focus is on the selection of upgrading strategies (UPS) (step 1) and later in their evaluation (step 2). Step 2 was repeated for the second assessment period in 2015; the impact assessment scores of this period constitute the FoPIA 2. Step 2 results are the impact assessment scores that will be utilized for the comparison between 2014 and 2015; they represent the main input data for the analysis in the thesis.

In Step 1 participants selected the UPS in a workshop were first a SWOT analysis of each UPS was performed, followed by secret voting ballot (Schindler et al. 2016, p. 54). The selected UPS per village could be reviewed inTable 4.

Step 2 purpose was to evaluate the impact of the selected UPS. In 2014 the farmers evaluated the UPS assumed impact (FoPIA 1 or T0 for now on) and in 2015 (FoPIA 2 or T1 for now on) their perceived UPS impact on FSC. They were asked to evaluate the UPS in a scale from -3 to +3 (+3 high positive impact, +2 moderate positive impact, +1 small positive impact, 0 no impact, −1 small negative impact, −2 moderate negative impact, −3 high negative impact).

In the 3 step a moderated discussion was also conducted to discuss differences in scorings and spark social learning by sharing of impact arguments (story lines) behind the scores. The research team (Trans-SEC staff) acted as moderator and was responsible for the collection of impact assessment results and field notes.

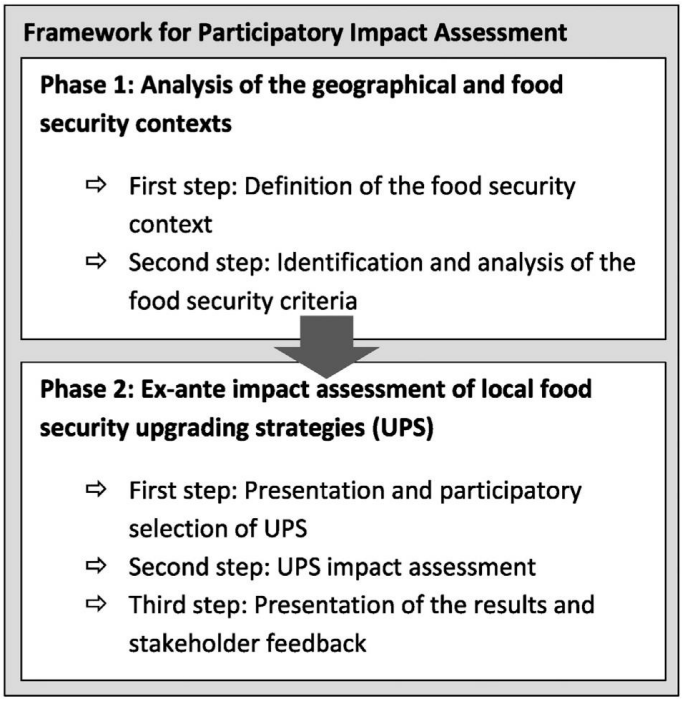

Figure 8 Implementation structure of the FoPIA to the case study of Tanzania. Source: Schindler et al. 2016, p. 53

Criterion	Sustainability Dimension	Farmer's definition	Food security dimension
Food diversity/ availability	Social	Sufficient number of meals(=3) per day offering a diversified and balanced diet	Access, Utilization
Social relations	Social	Community support during need. Family support and understanding of decisions about household resources	Access, Stability
Working condition	Social	Access to appropriate technology/equipment and agricultural practices, reducing working hours and work load	Access
Production/ Yield	Economic	Amount of food produced and available for family consumption and for selling	Access, Availability
Income	Economic	Family financial resources earned form agricultural production and off-farm activities	Access, Stability
Market participation	Economic	Selling and buying agricultural products and other needs; knowledge of market prices for improved negotiation power of farmers towards buyers	Access, Stability
Soil fertility	Environmental	Quality of the soil for agricultural production	Availability, Stability
Available soil water	Environmental	Soil water availability for agricultural production	Availability, Stability
Agrodiversity	Environmental	Cultivation of crop variety for family consumption and for selling; risk management in case of crop failure	Availability, Stability

Table 2 Farmer's definition of food security criteria. Source: Adapted from (Schindler et al., submitted for publication p.9)

FoPIA is structured around the Driver-Pressure-State-Impact-Response (DPSIR). DPSIR framework was developed in the late 1990s by OECD(2003), and the objective was to organize indicators such that decision makers could take informed decisions (Tscherning et al. 2012). FoPIA contrast with DPSIR because of the active discussion and participation of stakeholders to build the criteria of analysis.

The participatory analysis of criteria is the core functionality of FoPIA, and it is due to the increasing recognition of the value of participatory approaches for IAs (Morris et al. 2011). By using a portfolio of economic, social, and environmental food security criteria, FoPIA allows the integration of knowledge from different disciplines, researchers and stakeholders; Besides generating knowledge, it also facilitates the social learning process among stakeholder groups and researchers (König et al 2012).

Morris et al (2011 p.14) made emphasis in the capacity of FoPIA to “addresses the issues of complexity by facilitating integrated assessments”. In other words, FoPIA facilitates integration of knowledge. They refer to integration in a broad conceptual framework encompassing three broad meanings.

First the integration of analysis from different sectors; in the case of VC analysis this characteristic is useful to analyze assessments from different links in the chain. Second, integration of sustainability dimensions. FoPIA directly facilitates SIA by assessment of economic, social, and environmental concepts in an interrelated approach. Further, FoPIA actively encourages stakeholders to consider relationships between concepts. Third, integration of multidimensional or multifunctionality to assessments of sustainability; this is facilitated trough the selection of detailed indicators that represent, in the case of Morris et al (ibid) land use functions, and in this thesis, food security. Those indicators, yielded from the participatory approach, represent the range of economic, social and natural indicators locally relevant for the analysis.

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4.2. Comparing FoPIA 1 and FoPIA 2

In order to address the first research question, namely the comparison between ex-ante (FoPIA 1) and ex-post (FoPIA 2), the impact scores were statistically compared. For this purpose, three comparisons will compose the analysis; 1) comparison within village; 2) comparison between region; and 3) comparison across villages. Figure 9 presents the procedure-data analysis.

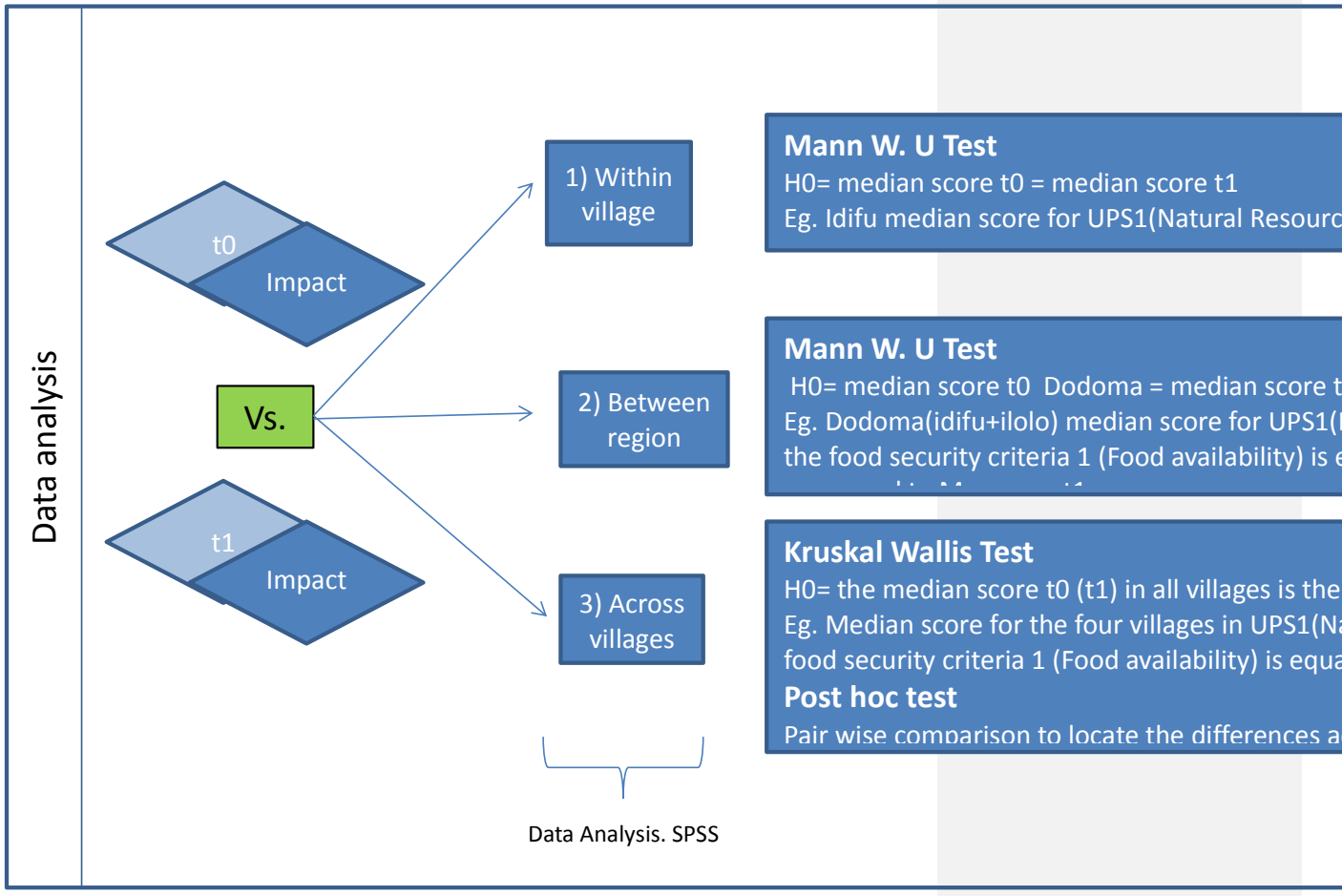

Figure 9 Data analysis

In 1) the scores obtained within the village in FoPIA 1 will be compared to the scores obtained within the village in FoPIA 2. This means, for example, that the

score for Idifu: upgrading strategy (UPS)=RWH/MF, food security criteria (FSC)=Food availability, will be tested for significant differences between t0 and t1; and the same apply for each FSC. For 2) the scores of the region will be compared between each other that is T0 vs. T0, and T1 vs. T1 for each UPS evaluated in each FSC. For example for UPS "kitchen garden" the scores in T0 in Dodoma will be compared with T0 scores in Morogoro. The last comparison is 3). This will compare the scores of each UPS across all villages at the same time. If differences are found on this comparison a post hoc analysis will be performed. This analysis consists of a pair wise comparison between villages in order to locate were the differences are.

Data characteristics

The data used for these comparisons is the impact scores obtained in the FoPIA 1 and 2. The scores assess farmer's expectations (t0) and farmer's perceived impacts (t1). Thus, the scores represent a qualitative assessment. Baker(2000, p. 2) recognizes that qualitative and participatory assessments can be used for impact analysis, and that this technique benefit from providing the beneficiaries view point. The scoring is individual but discussion was encouraged in the focus group.

In FoPIA 1 the *guiding* question posed to the farmer was:

> a) Positive scoring: In the 5 to 10 years to come, can the UPS "x" affect criteria "z" positively? If yes, on a scale 1 to 3 how strong will the positive effect be and why? If there is no positive or no affect at all, please score 0.
>
> b) negative scoring: In the 5 to 10 years to come, can the UPS "x" affect criteria "z" negatively? If yes, on a scale 1 to 3 how strong will the negative effect be and why? If there is no negative or no affect at all, please score 0.(Schindler 2014)

This guiding question reflects the ex-ante quality of the assessment. Scores for each farmer are recorded individually by Trans-SEC staff.

Guiding questions in FoPIA 2 are slightly different, reflecting an ex-post assessment. The questions are:

a) "*Does UPS x affect criteria y?*" [yes/no]

b) "How intense do you experience the UPS effect on criteria y?" (scale -3 to +3)

König et al.(2010, p. 2006) recognized that impact scores are an important outcome of the study, but another key outcome of implementing FoPIA is the "story lines" (impact arguments) behind the scores. These story lines reveal the beliefs and personal understanding of relations between UPS and food security criteria of farmers. The impact arguments will be used for the discussion section (section 6). Nevertheless, this point is perhaps a drawback of the thesis, since I could participate in none of the FoPIA missions. The impact arguments were only available as field notes collected by Trans-SEC staff during the 2014 and 2015 workshops. Nonetheless, through informal meetings for over 4 months with scientific coordinators of the project, this obstacle was overcome.

There was an evaluation assessment for each UPS implemented. All UPS were evaluated in nine food security criteria. Each participant scored the UPS in nine food security criteria (FSC); and participants could score from -3 to +3 depending on their perceptions (Table 3). That means that for UPS=RWH/MF, a matrix of scores 12x9 for t0, and 14x9 for t1, are produced (Table 4). Consequently, there are as many matrixes as there are active UPS. These matrixes are the input data for the statistical analysis-comparison. For example, in Idifu the assessment for UPS=Natural Resources, had 12 participants in t0 and 14 in t1

Participant characteristics						Food security criteria								
Region	UPS	Village	Participent name/ ID	Gender	Age	Food availability	Social relations	Working conditions	Production	Income	Market participation	Soil fertility	Available soil water	Agrodiversity
2 Regions	9 UPS	4 Villages	7-15 participants	female/male		Impact scores from -3 to +3								

Table 3 Data structure.

		RWH/MF		Kitchen Garden		Seed Tresher		Improved cooking stove		Sunflower pressing machine		Tree planting		Byproduct for bioenergy		Improved storage bags		Poultry integration	
		t0	t1	t0	t1	t0	t1	t0	t1	t0	t1	t0	t1	t0	t1	t0	t1	t0	t1
Region	Village	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Dodoma	Idifu	12	14	12	12	11	9	11	11	11	6	.	.	.	.	.	9	.	.
	Ilolo	13	12	10	11	13	4	.	8	12	7	13	14	.	.	.	6	.	.
Morogoro	Ilakala	9	10	10	11	12	7	.	11	.	.	.	.	12	6	11	7	.	.
	Changarawe	11	12	7	6	13	10	13	7	.	.	.	.	.	.	.	7	10	11

Table 4 UPS activity.

Empty cells means UPS was not active. N= number of participants in workshop. t0=FoPIA 1. t1=FoPIA 2.

Statistical tests

Mann Whitney U test

In order to assess significant differences between scores, the Man Whitney U test (MWUt) and the Kruskal Wallis test (KWt) were selected. MWUt will be used for the first two comparisons, that is within village and between regions; and the KWt will be used for the comparison across regions (figure XX).The Mann-Whitney U test (Mann, Whitney 1947) also known as the Wilcoxon Rank Sum test, is a non parametric test typically used to assess whether to groups are significantly different from each other. Is typically consider an equivalent of the Student's t test.

MWUt has diverse advantages that make it suitable for this analysis. For instance, since the impact scores are an ordinal variable measured in a likert scale MWUt is useful. Sawilowsky(2005, p. 599) argued that MWUtis particularly useful when the normality assumption is not meet; the variable under analysis is a rank or order; and is robust for small samples. These arguments coincide generally with those of Nachar (2008, p. 19).

Additionally, with the case of skewed data, the use of mean is problematic. The data set in the thesis is ordinal and skewed to the left, that is, the most frequent values are positive and growing, with the majority of values above 2 (for example see Figure 10). For this reason the use of the mean is not recommended, since it will suffer from outliers and skewness. The MWUt because uses the median, it can handle this characteristic on the data. Moreover, MWUt is usually preferred in the analysis of likert scales; and in the case of a seven point likert scale Winter, Joost C. F. de, Dodou (2010, p. 6) argued that data tends to be more skewed, therefore the use of MWUt is recommended.

Another important consideration regarding analysis with MWUt is relative to the study of the spread of the data. Hart(2001) reports that the use of MWUt is not just a test on differences in medians, but that the spread of the results could yield important information for the analysis. She recommends that the data should be described consistently because restricting the test only to differences in medians may not tell the whole story. Differences in spread of data might reveal underlying patterns.

The Mann-Whitney U test the null hypothesis (H0) that two groups come from the same population. That is that the two groups have the same distribution and are homogenous (Nachar 2008, p. 14). Depending on the requirements of the analysis, the alternative hypothesis (H1) test if the distributions are unequal for a two tailed test; or if the variable is sthochastically larger(smaller) than the other group, that is a H1 one sided test.

In the case of the thesis the MWUt is based on the comparison of each impact score per FSC from the first group with each impact score per FSC from the second group[1]. MWUt will rank the data in order, and run a comparison of all data together (both samples t0 and t1), testing the deviation from the expected 'U' for the common median if both groups will have been from the same population. For example, if H0 stipulates that the distributions are equal, each impact score of first group will have an equal chance of being larger or smaller than each score of the second group, that is to say a probability of one half (1/2). If a group is significantly different from the other without specifying the direction, then is possible to reject the H0. For the case that the analysis want to test if the impact scores, of the first group are significantly larger than those of the second, the H1 changes to an assessment of significant differences in one direction. Those hypotheses could be express as:

$$H_0: \theta_X = \theta_Y \text{ , } H_1: \theta_X < \theta_Y \text{ or } \theta_X > \theta_Y \text{ (one-tailed test)}$$
$$H_0: \theta_X = \theta_Y \text{ , } H_1: \theta_X \neq \theta_Y \text{ (two-tailed test)}$$

[1] The groups are defined differently depending on the comparison in case. For comparison withing village, the grouping variable is time of analysis, which is t0 or t1. For comparison between regions the grouping variable is region (Dodoma or Morogoro). Lastly, for the comparison across villages the grouping variable is the village.

where Θ is the median respectively for x and y group. In the thesis the H1 would be a two-tailed test. This will allow checking for differences only without testing the direction.

The verification of the hypothesis in a MWUt requires that the test meet the following assumptions (Nachar 2008, p. 15):

(a) Random selection of groups from the target population.
(b) Independence between groups. Each observation is from different participant.
(c) The measurement scale is ordinal or continuous.

Additionally Nachar(2008, p. 20) reported that the MWUt might give erroneous results if the variances are not equal. If heterocedasticity is present there are chances of type I error. In the case of distinct variances between groups, he proposed the use of t test with unequal variances as an alternative. In this thesis I will use a non parametric Levene test as described by Nordstokke, Zumbo(2010) to analysis this assumption.

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Kruskal Wallis test

The Kruskal Wallis test (KWt) is an extension of the MWUt for tests with more than two independent groups. It is also known as the H test (Kruskal, Wallis 1952). This test will be used for the third comparison, namely the comparison across villages (Figure 9). As the MWUt the Kruskal Wallis (KWt) is used and recommended for continuous and ordinal data (Vargha et al. 1998, p. 189). The purpose of the test is to test if the same form of distribution exist across groups and the population from which they came from (Chan, Walmsley 1977, p. 1761) without assuming a distribution beforehand. If the distributions are different, a post hoc analysis should be performed to identify where those differences in medians lie.

The assumptions of this test are analogous to that of the MWUt, with only the difference in number or groups to compare. Also, if used for only comparison of distributions the homogeneity of variances assumption might be not considered(Vargha et al. 1998, p. 178), although Ruxton, Beauchamp(2008)

recommends to test for this assumption. This assumption could be tested using a non parametric Levene test as proposed by Nordstokke, Zumbo(2010). This test also analyzes population medians through ranking the raw data. Additionally, Chan, Walmsley(1977, p. 1757)mention that ranking the data as in the KWt has the advantages of (1) the calculations are simplified, (2) only general assumptions on data distributions, (3) ordinal data could be used (4) robust enough compared with parametric test when assumptions for the latter are not met.

The null hypothesis in the KWt is that the samples come from identical population distributions. In comparison with the MWUt, the alternative hypothesis of this test changes. In the KWt the alternative hypothesis assumes that there is a difference between at least two of the groups (Bewick et al. 2004, p. 196). As such the KWt does not identify where those differences are, or whether they are significant. Thus a post hoc analysis should be made. In order to detect the location and significant differences between groups a pair wise comparison using the Mann Whitney U will be performed, since it is equivalent to a KWt with only two samples (Vargha et al. 1998, p. 188).

4.3. Household characteristics analysis

After comparing the results of FoPIA 1 and FoPIA 2, the next research question explores the household characteristics of the participants in the evaluation. In this section the methodology followed for this question is described. Descriptive statistics will be presented for each cluster in the next section.

This analysis uses the impact scores derived from FoPIA 1 and 2, but additionally trace back the household characteristics of the respondents. The household characteristics were collected by Trans-SEC project in a 2014 survey. During the focus groups the participants were asked for their household ID. This ID was traced back to the household survey to recover the household characteristics of every participant. Unfortunately some participants ID or information could not be triangulated to their household characteristics, therefore the sample was reduced. For FoPIA 1 there were 229 individual evaluations, from those only 173 participants

could be trace back to their household characteristics. Additionally for FoPIA 2 there were 246 individual evaluations, from those only 161 participants could be trace back to their household characteristics.

Whit the participants in the FoPIAs and their household characteristics matched, a comparison between them will be made in order to discover underlying patterns that may lead to differences in impact scores. To assess those differences two steps were followed. First a cluster analysis based on household characteristics of the participants was performed. The cluster is performed per UPS and per time of analysis. Second, once the clusters are formed, a comparison of impact scores between clusters will be done. This comparison will be an initial enquire to possible household characteristics that may influence impact scores. The comparison will use the same statistical tests as the section before. When the comparison is between two clusters only a MWUt will be used; when more than two clusters are formed, a KWt will be selected.

The idea behind the cluster comparison is to test the underlying characteristics of the clusters. Since the clusters tend to be heterogeneous, the characteristic that distinguishes one from the other, can be compared in a secondary test. Therefore these distinguishable characteristics will be assessed for differences in expectations and achieved impact results. Is hypothesized that different household characteristics will lead to differences in expectations and achieved results. The use of a statistical test to compare differences in scores will test this hypothesis.

Household characteristics

The variables used for the cluster analysis were obtained from a survey that Trans-SEC project carried out in 2014. From this comprehensive survey a selection of characteristics were extracted for the purpose of this thesis. The characteristics selected are: market distance in kilometres, household head, age of respondent, years of school, plot size, total of food expenditure per year, value assets in dollars, household nucleus size, perceived land security, fertility of the plot now, membership of political association and other occupation. The characteristics selected represent variables that have been used for analysis of food security by

different authors(Babatunde, Qaim 2009; Mutabazi et al. 2015; Tesfaye et al. 2011; Petrovici, Gorton 2005; Mason et al. 2015).

Market distance was measured in kilometres, although there were several households that sell their produce either at farm gate (0km) or in regional markets (>30km). To avoid such extremes the data was binned. The mean value for market distance overall is 13 km. Short is for answers from 0 to 11 km. Medium distance is from 12 to 25km. Finally long distance is for observations greater than 25km.More than 50% of the households sell at short distance from the market. Farmers will have the option to grow crops to market depending on the ability to reach it, thus this variable is important for decisions on UPS and their impacts.

The social characteristics of the households were represented by the following variables: household head, age, education, value assets, and household nucleus size. Household head was used to capture differences in impacts depending on gender. The great majority of households and UPS focus group participant are males. The rest of variables also represent social variables that influence decisions and impacts. Value assets might be used as a proxy of wealth.

Size of plot influences the capacity of the household to implement certain strategies, as well depending on the size of the plot interest and different impacts might be manifested. Plot size is reported for all land reported by respondent in acres.

Total food expenditure can be used to capture how interrelated a household is to the market, therefore the interests, expectations or impacts might be different depending on the household relation to the market.

Land tenure rights are a problem that has multiple ripple effects. In particular Changarawe households have problems with land tenure since some of their plots (or households) are part of a former sisal state. The variable perceived tenure status is used in the analysis to count for this external issue that perhaps affect expectations, decisions of implementation and achieved results. The data for tenure status was reported separately for each plot; this created a problem of classification. Some plots were perceived as secure others as not for the same household;

therefore a cut point has to be taken. I only considered the tenure of the cropland. Croplands include every other land use except homestead-garden. The other classifications are: rented out, permanent crops, annual crops, pasture, wood lot planted, natural forest, vacant land / fallow, business establishment and others. If any of these is reported “as not secure at all” then it was considered as not security over tenure (0 in dummy code). Mostly the biggest plots were the croplands and not the homestead. There were other four classifications more for perceived security, and “not secure at all” is only the extreme case. The other classifications are “somehow secure”, “almost secure” and “very secure”. There is a bias by not considering the homestead garden in the tenure classification; nevertheless most of the UPS are related to strategies that favourably consider the realm of the croplands rather than the homestead. The clear cut exemption is the kitchen garden strategy. This will be a drawback of this decision, which for ease of analysis may prove worth it.

Fertility of the plot was reported as “Unfertile”, “Somewhat fertile”, “Fertile”, “Very fertile” and “Not used for agriculture”. This will be a dichotomous variable where 0 will be for unfertile and 1 for anything else. In the case that respondents reported more than one plot with different fertilities, the procedure will be to take the biggest cropland plot and the fertility reported for it. This measure also makes for ease of analysis, otherwise there will be x number of cropland plots each with their own fertility assessment.

Social capital was captured by membership of political association. This variable reported households where at least one of the household members participated in a political association. Political associations included woman group, political parties, religious groups, village leaders (head and sub head), village committee, cooperatives and farmers groups.

Some household may be involved in a variety of livelihoods, to capture this diversifications strategy the variable other occupation was used. The survey collected information about second other occupation if any. If households reported a second occupation this variable will take the value of 1, and 0 if not. This variable

will capture whether the household principal activity is agriculture or else, therefore preferences, interest and engagement in one or other UPS will depend (theoretically) in the importance of agriculture for each household. Farmers reported in the survey the following second activities: casual off-farm labour in agriculture, casual off-farm labour in non-agriculture, casual labour, performing only occasional and light work, permanently employed in agriculture, permanently employed in non-agriculture, government official, non-farm owned business, hand craft, iron smith, engaged in fishing, hunting, collecting or logging, groundnuts business, selling local alcohol, entrepreneur, carpenter, pastor. Additionally some participants reported household chores, nevertheless is assumed as a not remunerated activity and thus not considered in the analysis. Is a fact that the influence of time spent in household activities negatively affects the time available for other remunerated activities, nevertheless for this study this is off the scope.

Two step cluster analysis

After tracing back focus group participants to household characteristics a two step cluster analysis will be performed. Cluster methods are used to differentiate categories of respondents in to a common underlying structure. The procedure tries to maximize homogeneity within each cluster, while increasing heterogeneity across other clusters(Hair et al. 1998). This procedure is part of a family of data dimensionality reduction techniques which enable creating subgroups from a population.

The objective of cluster analysis is to identify groups of cases, in this thesis group of farmers, which have similar characteristics. There are different procedures to cluster respondents. Those approaches are: hierarchical methods, k-means (partitioning methods), and two-step clustering. For this thesis the two step cluster procedure will be used.

The variables used for clustering are the input that this procedure uses to group farmers. Depending on the variables and their information, is that the algorithm clusters participants in to one group or the other. Therefore the deciding on which variables to use is important. The variables were described above. Those variables

are categorical and continuous. For this reason, two step cluster was chosen as a procedure for clustering

Two step cluster was first developed by Chiu et al.(2001) as a technique specially designed to handle continuous and categorical variables. The procedure is a combination of the other two clustering methods. Additionally is a standard procedure in SPSS 23. The procedure is based on two stage approach. The first stage is similar to that of k means. In this step pre-clusters are formed to reduce the size of the matrix of results, and thus increase the speed of calculations. These pre-clusters are then used in the second stage. The second stage SPSS uses the standard hierarchical clustering algorithm.

Because categorical variables are used, the distance for selecting cluster is the log-likelihood criterion. Additionally SPSS could be used to automatically decide the number of clusters based on Schwarz Bayesian Criterion or the Akaike information criterion. Nonetheless, due to generally a small sample, a decision to use two clusters was specified before hand; only when the cluster quality was poor, more clusters were added.

The idea behind using the two step cluster analysis is to make no assumptions of underlying constructs; therefore the algorithm is left to chose, within the characteristics provided, the differentiating characteristics in order to make the clusters heterogeneous. In this way it makes possible the comparison between farmers clusters based on the underlying household characteristics of the focus group assessing the UPS. Because the algorithm sets clusters aside in its own, there is no way to control for which characteristic to separate them; this has advantages and disadvantages. First, as an advantage, the approach avoids bias in selecting characteristics for clustering. Nonetheless there is no possibility to select a variable to focus the study, this is the disadvantage. Nonetheless this serves as an explorative inquire to household characteristics that could be associated to certain expectations or achieved impact results.

5. Results

The statistical analysis compares ex-ante (T0) impact assessments with present (T1) impact assessments of upgrading strategies (UPS) on food security criteria (FSC) for the four case study sites (CSS). The first subchapter corresponds to the first research question, regarding impact assessment score differences between the two assessment periods (FoPIA 1 and 2). Three comparisons are presented: 1) within village, 2) between regions and 3) between villages. The second subchapter (6.4) presents the analysis of household characteristics, which correspond to the second research question that analyses possible trends between household characteristics and scores.

5.1. Comparing FoPIA 1 and FoPIA 2: Within Villages comparison

Idifu

Idifu participated in six UPS: a) “rain water harvesting and micro fertilizing” (RWH&MF) b) “kitchen garden”, c) “seed thresher” d) “improved cooking stove” e) “sunflower oil pressing” and f) “improved storage bags” (only active in FoPIA 1).

The scores of both assessments are predominantly skewed to the left (Figure 10, Figure 11) indicating that the majority of UPS averaged positive scores in both assessment periods. FoPIA 1 had mainly positive scores ranging from 0 to +3, with the exceptions of “kitchen garden” and “sunflower oil processing”. In “kitchen garden” the scores for *soil fertility* criteria were spread from -3 to +3 nonetheless the averaged expected impact score is 0.00 (no impact). In the case of UPS “sunflower oil processing”, the *agrodiversity* criteria had an expected score of -1.00 score. Farmers mentioned that sunflower is weak when grown with other crops. Thus allocating all their plots to sunflower will reduce the opportunity to grow other crops.

FoPIA 2 had mainly positive scores ranging from 0 to +3. In “kitchen garden” UPS, the scores for *working conditions* criteria had the biggest spread from -3 to +3 nonetheless the impact median is+3. RWH/MF impact still had some negative scorings, yet none of the medians is negative. The score for criteria *food availability*

is the lowest. Farmers mentioned that a lack of rainfall and late grow of seeds were the drivers.

"Rain water harvesting and micro fertilizing"

RWH/MF had an overall assessment decline compared to T0. Economic and social conditions got 1.13 average points less than expected. The biggest FoPIA 1 versus FoPIA 2 differences are for *income* ($p \leq 0.05$), farmers mentioned that lower water availability constrains production thus reducing income; and for *market participation* ($p \leq 0.001$) (Table 5), in this case farmers mentioned that there are no markets available for the produce.

"Kitchen garden"

"Kitchen garden" UPS had a slight average positive increase from T_0 to T_1. Significant differences were found on *social relations* ($p \leq 0.05$) and *soil fertility* ($p \leq 0.001$) (Table 5). Both changes were positive, and the biggest is soil fertility that changed from 0.70 to 2.58. Regarding the latter farmers mentioned that using manure in bags increases fertility.

Another interesting result is the change in spread of *working conditions*, although non- significant. The scores changed from a entirely positive distribution in T0 to -3 to +3 in T1 (Figure 10, Figure 11). This reflects a work load miscalculation. Farmers commented water availability as a major concern.

"Seed thresher"

In the UPS "seed thresher" there was an average slight positive adjustment from T0 increasing 0.48 points. Generally expectations were high and achieved averaging 1.89 in T0 and 2.37 in T1. Economic and environmental dimension got the biggest changes. Almost a point of difference from expectations was found for criterion *production, income, soil fertility and agrodiversity*. However none of the changes were significant (Table 5). Nonetheless the spread of the results changed concentrating favourably in the positive side (Figure 10, Figure 11). Farmers mentioned that increased income and work efficiency will directly or indirectly impact all food security criteria (FSC).

"Improved cooking stove"

"Improved cooking stove" UPS had a slight positive increase from expectations increasing and average of 0.60 points (Table 5). The economic dimension was expected to yield the most impact averaging 1.91 in T0. These expectations were generally achieved in T1, with the exception of *market participation* that was scored -0.36 points less than T0 although this change is not significant.

However, *working conditions* did have a significant difference change ($p \leq 0.001$)(Table 5). In FoPIA 1 the expectations of impact in working conditions was almost none (0.27), but in T1 an average score of 2.18 was reported (Table 5). Farmers mentioned that reductions in work load and increased spare time for other activities were the consequence of using the improved stoves.

"Sunflower oil pressing"

The "sunflower oil pressing" UPS was not completely implemented in Idifu during the period of evaluation. Therefore impact scores in FoPIA 2 need to be considered as still ex-ante evaluation. In all FSC there was an average increase of 0.5 from FoPIA 1 to FoPIA 2 (Table 5) except for the criterion *food availability* that remained with a high score of 2.33 decreasing 0.03 from T0.

Significant changes were found on *income* ($p<0.05$) (Table 5). This may be attributed to T1 farmer's comments expected increased income through the use of the sunflower press machine. They related this to a diversified portfolio of livelihoods and to the advantage that there is no such business enterprise in the surrounding villages therefore allowing them to possibly provide pressing services.

Additionally *agrodiversity* had a significant change ($p<0.01$) (Table 5), regarding this change farmers commented that the income obtained through the UPS will allow to increase the diversity of cultivated and bought crops, also, they mentioned that, the by-products of the pressing (seed cake) could be used as a feedstock.

"Improved storage bags"

Idifu also participated of the UPS Improved storage bags. This UPS was only active in FoPIA2, therefore no comparison was possible. Regarding scores for T1 this UPS is regarded as highly beneficial. The economic followed by the environmental dimensions have the highest scores, 2.78 and 2.63 in average respectively (Table

5). Farmers regard that the market participation criteria would be highly impacted by this UPS, the score was+3.

			RWH/MF		KitcGard		Seed Tresher		Improved cooking stove		Sunflower pressing machine		Improved storage bags
			t0	t1	t0	t1	t0	t1	t0	t1	t0	t1	t1
	Sustainability Dimension	Food Security Criteria	average	average	average	average	average	average	average	average	average	average	average
Idifu	SOC 1	Food availability	1.58**	0.50**	1.42	2.00	2.36	2.67	1.27	1.91	2.36	2.33	2.44
	SOC 2	Social relations	2.79	1.79	2.42*	2.83*	2.45	2.67	2.09	2.73	1.91	2.50	2.33
	SOC 3	Working conditions	2.42	1.64	1.00	1.67	2.64	2.67	0.27***	2.45***	1.73	2.50	2.78
	ECO 1	Production	2.71	1.93	2.13	1.83	2.00	2.89	1.82	2.09	1.82	2.50	2.44
	ECO 2	Income	2.71*	1.21	2.17	2.17	1.91	2.89	1.91	2.18	1.45*	3.00*	2.89
	ECO 3	Market participation	2.83***	1.21*	2.33	2.08	2.27	2.44	2.00	1.64	1.73	2.83	3.00
	ENV 1	Soil fertility	2.58	2.57***	0.71***	2.58***	1.09	1.89	0.00	1.00	1.18	2.00	2.78
	ENV 2	Available soil water	2.58	2.64	0.75	1.50	0.00	0.22	0.00	0.00	2.36	2.67	2.22
	ENV 3	Agrodiversity	2.58	2.29	0.75	2.08	2.27	3.00	0.45	1.18	(-0.09)**	3.00**	2.89

Table 5 Comparison within village: Idifu. * Criteria with a significant difference (α≤0.05). ** Criteria with a significant difference (α≤0.01). * Criteria with a significant difference (α≤0.001).**

Iloilo

Iloilo participated in seven UPS: a) RWH/MF, b) “kitchen garden”, c) “seed thresher”, d) “improved cooking stove”, e) “sunflower oil pressing”, f) “improved storage bags” and g) “tree planting”. UPS d) and f) were only active in FoPIA 2 (Table 17).

Scores of both assessments are predominantly skewed to the left (Figure 12, Figure 13) indicating that the majority of UPS averaged positive scores both for T0 and T1. FoPIA 1 had mainly positive scores ranging from 0 to +3, with the exceptions of RWH/MF and “tree planting”. The T0 scores for the latter spanned to the -1 points range, nonetheless all medians were positive. FoPIA 2 had particular results especially for “improved storage bags”. This UPS was not fully active and the field notes reported that the participants were not engaged with the UPS, and also frustrated with the price of the bags.

“Rain water harvesting and micro fertilizing”

The scores for UPS RWH/MF had an overall slight negative adjustment from T0 to T1. Furthermore, from already low expectations (average 1.44), the scores in T1 averaged 0.20 points less (average1.24) (Table 6).

Social relations criteria increased 1.13 points (P≤0.05). Regarding this change farmer’s reported that increased yields will improve social relations. Additionally, the criteria *soil fertility* had a significant negative change (P≤0.001) from 2.69 in T0 to 1.41 in T1. Farmers reported that additional fertilizer will need to be purchased; this might be unaffordable for some. (P≤0.05) (Table 6). Further *available soil water* had also a significant negative decline from 2.69 in T0 to 1.5 in T1 (P≤0.01) (Table 6). Farmers reported that the specific knowledge required to construction of tied ridges may be difficult to develop.

“Kitchen garden”

“Kitchen garden” UPS had an average positive increase from T0 to T1 of 0.62 points. Generally the environmental dimension had the biggest changes with an average increase of 1.60. This change is a reflection of a change in perception, were in T0 farmers saw no relation between this UPS and the environmental dimension, the opposite happened in T1. However significant differences (P≤0.05)

were found only on *soil fertility* criteria (Table 6). Farmers mentioned that knowledge acquired in manure management could also be used in other plots, thus increasing soil fertility.

In the economic dimension, *income and market participation* had a slight negative decline, however impact assessment in T1 are still high averaging 2.45 and 2.36 points respectively(Table 6).

"Seed thresher"

For UPS "seed thresher" there was an average negative decline of 1.24 points compared to T0. Farmers were frustrated because the machine is not at the site yet, these explain the negative assessment results. All sustainability dimensions have significant changes. An average decline difference from T0 to T1 of 1.89 points was found for criterion *food availability* (P≤0.05), *working conditions* (P≤0.01), *income* (P≤0.05*), market participation* (P≤0.01*), and agrodiversity* (P≤0.05) (Table 6). However no comments from the farmers were expressed regarding the negative scores for social and economic dimensions, the frustration may explain the negative assessment.

The environmental dimension was poorly understood in the focus group (field notes). This reason could explain the negative scores.

Further, farmers in Fopia1 found relations between working conditions and the UPS, however in FoPIA 2 farmers score 0 for this criterion, although commented that in the future this UPS will ameliorate working conditions.

"Sunflower oil pressing"

"Sunflower oil pressing machine" has not been completely active in Ilolo. There was low production of seeds in the season to operate the machine. Additionally it was found that the economic viability of the project may not be feasible (Table 17).

The focus groups still evaluated the impacts of the UPS. For these two main problems the scores in FoPIA 2 declined an average of 0.96. The biggest change is in *food availability* that had an average of 0.00 in T1 (P≤0.001)(Table 6). Interestingly the field notes confirm the awareness of interaction between the UPS and this criterion, however farmer's assessment score did not reflected the

interaction. This may be due to the implementation status and the dry spell that reduced production yields.

All social dimensions had significant changes; f*ood availability* (P≤0.001)*, social relations* (P≤0.01) and *working conditions* (P≤0.01)(Table 6). Additionally *production* (P≤0.01) and *soil fertility* (P≤0.05) had significant changes (Table 6).

"Tree planting"

Social and economic dimensions had a score decline compared with T0 of 0.95 points in average. However, only *production* criterion had significant differences (P≤0.001) from 2.62 in T0 to 0.07 in T1 (Table 6). Field notes mentioned that perhaps farmers misunderstood the question for production criteria.

The environmental dimension expectations were consistent with results. Farmers are aware of the interrelations of this UPS with the food security criteria. Although some of the benefits will come when the trees mature, farmers still scored positive some benefits like trees foliage for increase soil fertility, shading for water retention and forage for livestock.

"Improved storage bags" and "Improved cooking stove"

Ilolo also participated of the UPS improved storage bags and improved cooking stove. These UPS were only active in FoPIA 2 therefore no comparison of expectations and results was possible.

			NatRes		KitcGard		Seed Tresher		Improved cooking stove		Sunflower pressing machine		Tree planting wood supply		Improved storage bags	
			t0	t1	t0	t1	t0	t1	t0	t1	t0	t1	t0	t1	t0	t1
	Sustainability Dimension	Food Security Criteria	average	average	average	average	average	average	average	average	average	average	average	average	average	average
Ilolo	SOC 1	Food availability	1.31	0.75	2.30	2.64	2.46*	1*	.	0.75	2.5***	0***	1.62	1.36	.	0.67
	SOC 2	Social relations	0.61*	1.75*	2.50	2.55	2.08	2.00	.	2.00	2.67**	1.43**	2.46	1.21	.	0.50
	SOC 3	Working conditions	1.42	1.25	2.50	2.82	2.30**	0**	.	2.25	2.5**	1**	1.69	1.14	.	0.67
	ECO 1	Production	1.38	0.33	2.10	2.73	2.46	2.00	.	1.00	2.83**	1.71**	2.62***	0.07***	.	0.17
	ECO 2	Income	1.08	0.42	2.60	2.45	2.23*	0.5*	.	0.63	2.50	1.71	2.08	1.86	.	-0.17
	ECO 3	Market participation	1.23	1.42	2.80	2.36	2.61**	0.5**	.	0.38	2.50	1.71	2.15	1.29	.	0.00
	ENV 1	Soil fertility	2.69***	1.41***	0.60*	2*	1.31	0.00	.	1.13	2.17*	0.71*	1.69	1.79	.	0.33
	ENV 2	Available soil water	2.69**	1.5**	0.60	2.45	1.08	1.25	.	0.75	0.00	0.43	2.00	2.00	.	0.17
	ENV 3	Agrodiversity	0.58	2.33	1.10	2.64	1.84*	0*	.	1.00	1.00	1.29	2.00	2.21	.	0.50

Table 6 Comparison within village: Ilolo.

*** Criteria with a significant difference (α≤0.05). ** Criteria with a significant difference (α≤0.01). *** Criteria with a significant difference (α≤0.001).**

Ilakala

Ilakala participated in six UPS: a) RWH/MF, b) “kitchen garden”, c) “seed thresher”, d) “improved cooking stove”, f) “improved storage bags” and g) “byproduct for bioenergy”. UPS d) was only active in FoPIA 2.

Scores of both assessments are predominantly skewed to the left (Figure 14, Figure 15) indicating that the majority of UPS averaged positive scores both for T0 and T1. In FoPIA 2 there is a decline in medians. FoPIA 1 had mainly positive scores ranging from 0 to +3, with the exceptions of “byproduct for bioenergy” and “seed thresher” which spanned to the -1 points range, nonetheless all medians were positive. On the other hand FoPIA 2 *working conditions* in UPS “kitchen garden” had score results that ranged from -2.

Rain water harvesting and micro fertilizing

The scores for RWH/MF were on average 1.03 points less than expected (T0). Furthermore, all FSC scores had a negative adjustment. The change was significant for all economic criteria, *production* (P≤0.001), *income* (P≤0.001), *market participation* (P≤0.05) (Table 7). For these changes farmers reported that the results of pigeon pea in combination with maize was not as expected, reduction of production; also that the yields were not enough to have surplus to bring to market, reduction in market participation.

Additionally, significant changes in criteria *food availability* (P≤0.001) and *social relations* (P≤0.05) were found (Table 7). The arguments behind these changes in social dimension are related to: low yield of sesame trials; confusion about the involvement of the community and group members; conflicts with livestock keepers; and work load underestimations.

Soil fertility (P≤0.001) had significant negative adjustments from expectations, but the impact still is high (2.0) (Table 7). Farmers reported that additional fertilizer will need to be purchased to maintain soil fertility.

"Kitchen garden"

"Kitchen garden" UPS had an average negative decline of 0.85 points, from 2.44 in T0 to 1.60 in T1 (Table 7). The environmental dimension had the biggest change with an average decline of 0.97 points; *soil fertility* had the biggest change overall from 2.40 in T0 to 1.00 in T1. However no significant differences were found on any FSC. Farmers did not mentioned any specific issue, thus the expectations might were overoptimistic.

For the *working conditions* criteria the scores spread changed considerable from expectations, reflecting a change in perceptions. Farmers expected at least to have no impact, but in FoPIA 2 there are scores that span till -2 (Figure 14, Figure 15). This may evidence that farmers have not considered all extra work in their first assessment. Farmers commented that fetching additional water for the kitchen garden during dry periods is problematic.

"Seed thresher"

In the UPS "seed thresher" there was an average slight decline in scores of 0.48 points compared to T0. Generally expectations for economic dimension in T0 were high (2.14 in average) and in fact exceeded by small margin in T1 (2.43 in average); none of this changes were significant (Table 7).

The social dimension had mix results. The expectations in T0 for criterion *social relations* and *working conditions* were slightly exceeded in T1 by an average of 0.13 points, which is contrast to farmer's comments regarding troubles to bring the machine to close to the fields. On the other hand *food availability* had a decrease from T0 of 0.93 points; this change was significant ($P \leq 0.05$) (Table 7).

The environmental dimension had the biggest changes from expectations. The scores for *soil fertility* ($P \leq 0.05$) and *available soil water* ($P \leq 0.001$) had significant changes while agrodiversity did not. Farmers mentioned that the machine increases efficiency, and that profits could be used to buy fertilizers or other crops. Importantly is the change in perception regarding the relation between the UPS and criteria *available soil water. Where* farmers saw a relation in T0 (average score 2.33), they

no longer attribute that for T1 (average score 0.00) this change is highly significant (P≤0.001) (Table 7, also see Figure 14, Figure 15).

"Byproduct for bioenergy"

Overall impact expectations (T0) were not met by an average of 0.45 points. The economic dimension had the biggest decline compared to T1, although only the *income* criteria had significant changes (P≤0.05) with a change from 2.75 in T0 to 1.83 in T1 (Table 7).

In the environmental dimension, scores for agrodiversity were 0.83 points less than expectations in T0, this change was significant (P≤0.05). No further comments were recorded for this change.

Farmers commented that the pyrolizer is too hot to operate while cooking; adjustments need to be done to the prototype (Table 17).

Improved storage bags

This UPS did not meet the expectations of T0 by an average of 1.49 points. With the exception of *soil fertility* and *available soil water*, all FSC had significant changes. Additionally *social relations* criteria had a decline in assessments but the assumption of homogeneity of variances was not met. Farmers still see a relation between the UPS and positive impacts, but not as strong as before.

In the social dimension significant changes were found for criteria f*ood availability* (P≤0.01), s*ocial relations* (P≤0.001) and w*orking conditions* (P≤0.05) (Table 7). Farmers commented that the UPS will encourage more production, better quality; and additionally the UPS give them bargaining power because they can store the grains and wait for better prices (field notes).

The economic dimension had an average decline of 1.29 points with significant changes in all three criteria, *production* (P≤0.05), *income* (P≤0.001) and *market participation* (P≤0.05) (Table 7).

Agrodiversity criteria had a decline of 2.74 compared to T0 (P≤0.001) (Table 7). Despite that farmers acknowledged a relation between this UPS and agrodiversity criterion in FoPIA 1 this seems not to be the case for FoPIA 2, reflecting a change in

perception (see also Figure 14, Figure 15) Farmers did not further comment this change.

			RWH/MF		KitcGard		Seed Tresher		Improved cooking stove		Byproduct for bioenergy		Improved storage bags	
			t0	t1	t0	t1	t0	t1	t0	t1	t0	t1	t0	t1
	Sustainability Dimension	Food Security Criteria	average	average	average	average	average	average	average	average	average	average	average	average
Ilakala	SOC 1	Food availability	3***	1.40***	2.70	2.18	2.50*	1.57*	.	2.45	1.58	1.17	2.82 **	1.29**
	SOC 2	Social relations	3*	2*	2.80	2.00	2.17	2.29	.	2.64	2.42	2.00	3a***	1a***
	SOC 3	Working conditions	2.89	2.20	1.50	0.82	2.58	2.71	.	2.91	2.00	2.33	3.00	1.86*
	ECO 1	Production	3***	1.70***	2.80	1.82	1.75	2.57	.	1.55	2.58	1.50	2.64	1.71*
	ECO 2	Income	2.94***	1.30***	2.80	1.64	2.17	2.29	.	1.64	2.75*	1.83*	2.82	1.29***
	ECO 3	Market participation	1.83*	0.80*	2.50	1.91	2.50	2.43	.	1.27	2.08	2.17	2.27	0.86*
	ENV 1	Soil fertility	2.94***	2***	2.40	1.00	2.25*	0.43*	.	0.27	1.75	1.67	1.55	0.86
	ENV 2	Available soil water	2.94	2.40	2.40	1.09	2.33***	0***	.	0.36	2.25	1.50	1.73	0.29
	ENV 3	Agrodiversity	2.78	2.30	2.10	1.91	2.25	1.86	.	1.18	2.50*	1.67*	2.45***	(-0.29)***

Table 7: Comparison within village: Ilakala. * Criteria with a significant difference (α≤0.05). ** Criteria with a significant difference (α≤0.01). * Criteria with a significant difference (α≤0.001).**

Results for Changarawe

Changarawe participated in six UPS: a) RWH/MF, b) “kitchen garden”, c) “seed thresher”, d) “improved cooking stove”, f) “improved storage bags” and g) “poultry integration”. UPS f) was only active in FoPIA 2.

Scores of both assessments are predominantly skewed to the left (Figure 16, Figure 17) indicating that the majority of UPS averaged positive scores both for T0 and T1. An interesting case is improved cooking stoves. This UPS was not expected to have high impacts, averaging 0.39 score in FoPIA 1. On the other hand this UPS was perceived as highly beneficial in FoPIA 2. Further Changarawe seems to have either high impacts or no impacts in FoPIA 1, while in FoPIA 2 the assessment is more conservative and in the medium positive range.

“Rain water harvesting and micro fertilizing”

The scores for UPS RWH/MF were on average 0.41 points less than expected. Although there is a reduction from expectations, the average impact in T1 is 1.90.

All criterions in environment dimension had a negative average decline of 0.38 points in T1, were significant changes were found for *soil fertility* (P≤0.05) and *available soil water* (P≤0.05) (Table 8).

The economic dimension had mix results with market participation increasing 0.48 points compared to T0 and *production* and *income* scores reducing an average of 0.66 points; only the change in *income* score was significant (P≤0.05) (Table 8).

The biggest significant change from T0 was in social dimension for *working conditions* (P≤0.001) (Table 8), this criterion scores spanned to -2 points in T1, whereas in T0 +1 was the lowest expected impact (see Figure 16, Figure 17). This change reflects a change in perception and a miscalculation of work load. Farmers reported that lack of experience was troublesome for building the tied ridges; additionally identifying proper spacing maize for intercropping was difficult.

"Kitchen garden"

"Kitchen garden" UPS had a negative decline from average score of 1.97 in T0 to an average score of 0.80 in T1; a decline of 1.17 points in average. Whit the exception of agrodiversity criterion, all other FSC had a decline from T0 to T1.

Working conditions criterion had significant changes (P≤0.001) with a change from 3.00 in T0 to 1.67 in T1 (Table 8). Farmers commented that sourcing materials needed for the garden was troublesome.

All criteria in economic dimension had a significant decline compared to T0. *Market participation* had the biggest change, even averaging a negative impact (-0.33) in T1 (P≤0.001) (Table 8). Regarding market participation, farmers reported that surplus from the "kitchen garden" is been sold locally, but also farmers reported that this leads to people going less to acquire produce from the market thus reducing businesses. Additionally *production* (P≤0.001) and *income* (P≤0.001) had significant changes (Table 8).

In the environmental dimension, changes in available soil water and agrodiversity were significant (P≤0.001) (Table 8); however these tests did not meet the assumption of homogeneity of variances. Additionally the field notes reported that the question of agrodiversity was not well understood.

Importantly is the change in perception; the changes are so drastic because in T0 farmers saw no relation between this UPS and the environmental criterions but, in the other hand in T1 they saw the relation, this change is evidenced with the change in impact assessment from 0.00 in T0 to 1.83 in T1 (Table 8), and in the change of spread (Figure 16, Figure 17).

"Seed thresher"

In the UPS "seed thresher" there was an overall negative decline from an average 1.81 in T0 to 0.77 in T1, an average decline of 1.01 (Table 8).

Generally expectations in T0 for economic and social dimension were high (average of 2.31) however scores in T1 averaged 1.12 (Table 8). Score changes for *food availability* (P≤0.001), *production* (P≤0.01) and *market participation* (P≤0.01)

criterions were significant (Table 8). Farmers commented that the machine came late; therefore they could not take full advantage of it for this season market.

Regarding the environmental dimension, *agrodiversity* criterion had significant changes (P≤0.05). In T1 farmers reported that this UPS had an interrelation with this criterion (score of 1.08), whereas in T2 they do not acknowledge it score of (0.00) (see also Figure 16, Figure 17) reflecting a change in perception.

"Improved cooking stove"

Overall expectations in T0 were meagre but the results of T1 were surprisingly higher by an average of 1.99 points (Table 8). With the exception of *market participation*, all FSC had highly significant changes: f*ood availability* (P≤0.001), s*ocial relations* (P≤0.001), *working conditions* (P≤0.001), *production* (P≤0.001), *income* (P≤0.01), *soil fertility* (P≤0.001), *available soil water* (P≤0.001) and *agrodiversity* (P≤0.001) (Table 8).

Important to highlight is the significant changes in the environment dimension evidence of change in perception that averaged 0.3 in T0 and 2.19 points in T1 (Table 8). Whereas in T0 farmers saw no relation between the UPS and this dimension, for T1 they did (see also Figure 16, Figure 17). Farmers reported that the UPS will decrease consumption of wood, and trees will be saved thus increasing soil fertility and water availability.

The biggest change was in *production* criteria, from an impact assessment of 0.15 in T0 to 2.71 in T0 (P≤0.001) (Table 8). Farmers commented that the time saved for cooking allows them to allocate surplus time to other productive activities.

"Poultry integration"

This UPS did not meet the expectations (T0) by 0.91 points that is a decline from 2.42 in T0 to 1.52 in T1. In the social dimension significant changes were only found in *food availability*, with an average decline of 1.44 points (P≤0.001) (Table 8). Farmers commented that low rainfall affected production.

In the economic dimension, with the exception of market participation, the score changes in T1 for *production* (P≤0.05) and *income* (P≤0.001) were significant (Table

8). Farmers commented that because the UPS still in its infancy the input requirements act as an entry barrier for some farmers.

Regarding the environmental dimension, *soil fertility* criteria had also significant changes (P≤0.05) with a decline from 2.70 in T0 to 1.91 points in T1 (Table 8). No further comments were made from the farmers.

Changarawe implemented improved storage bags only in FoPIA2, therefore no comparison of results was possible.

			RWH/MF		KitcGard		Seed Tresher		Improved cooking stove		Improved storage bags		Poultry integration	
			t0	t1	t0	t1	t0	t1	t0	t1	t0	t1	t0	t1
	Sustainability Dimension	Food Security Criteria	average	average	average	average	average	average	average	average	average	average	average	average
Changarawe	SOC 1	Food availability	2.05	2.17	3.00	2.50	2.54***	1***	0.31***	2.29***	.	2.00	2.8***	1.36***
	SOC 2	Social relations	1.95	2.25	2.71	1.17	2.23	1.40	0.38***	2.71***	.	2.14	2.70	1.55
	SOC 3	Working conditions	1.86***	(-0.25)***	3***	1.67***	2.08	1.00	0.23***	2.71***	.	2.43	2.10	1.09
	ECO 1	Production	2.86	2.33	3***	1.50***	2.38**	0.80**	0.15***	2.71***	.	1.29	2.40*	1.27*
	ECO 2	Income	2.55*	1.75*	3***	1.33***	1.77	1.30	0.38**	2.43**	.	1.71	2.70***	0.91***
	ECO 3	Market participation	1.68	2.17	3***	(-0.33)***	2.85**	1.20**	2.00	2.00	.	2.71	2.30	1.91
	ENV 1	Soil fertility	2.55*	1.83*	0.00	-0.67	0.92	0.20	0***	1.71***	.	0.86	2.70*	1.91*
	ENV 2	Available soil water	2.55*	2.17*	0***a	(-1.83)***a	0.46	0.00	0***	2.29***	.	0.29	1.70	1.36
	ENV 3	Agrodiversity	2.73	2.67	0***a	1.83***a	1.08*	0*	0.08***	2.57***	.	2.57	2.40	2.27

Table 8 Comparison within village: Changarawe. * Criteria with a significant difference (α≤0.05). ** Criteria with a significant difference (α≤0.01). * Criteria with a significant difference (α≤0.001).**

5.2. Comparing FoPIA 1 and FoPIA 2: Between regions comparison

This section presents the results for the comparison between regions were T0 and T0 and T1 and T1 scores are statistically compared. For example, expectations in T0 of UPS "RWH/MF" in Dodoma are compared with expectations in T0 of the same UPS in Morogoro. The following UPS were active in at least one village in both regions: "rain water harvesting and micro fertilizing" (RWH/MF), "kitchen garden", "seed thresher", "improved cooking stove" and "improved storage bags". The results for this comparison are presented in Table 9

Rain water harvesting and micro fertilizing

The UPS scores for RWH/MF in both regions were similar for the two assessments periods (T0 and T1). Dodoma averaged 1.99 in T0 while Morogoro averaged 2.56 points in the same period. In T1 there is a slight decline in impact assessments but Morogoro is ahead of Dodoma with an impact assessment score of 1.50 and 1.84 respectively (Table 9).

However, in T0 only significant differences were found for *food availability* criteria (P≤0.001), where expectations for this UPS were 1.08 higher in Morogoro (Table 9).

While the impacts assessments in T1 for both regions are less than those expected in T0, Morogoro results are still higher than Dodoma. Only significant differences were found for *food availability* criteria (P≤0.001), where results for this UPS were 1.16 points higher in Morogoro (Table 9). The rest of FSC had no significant differences.

"Kitchen Garden"

For T0 Morogoro averaged 2.21 compared to Dodoma that averaged 1.71, although score differences existed in all FSC, no statistically significant differences were found in this period (Table 9).

On the other hand, T1 showed an opposite trend. Dodoma T1 scores for all FSC are in average 1.10 points higher than Morogoro. Whit the exception of *food availability* and *agrodiversity*, the rest of criterions had significant differences: s*ocial*

relations (P≤0.01), *working conditions* (P≤0.001), *production* (P≤0.05), *income* (P≤0.01), *market participation* (P≤0.01), *soil fertility* (P≤0.001) and *available soil water* (P≤0.001) (Table 9).

"Seed thresher"

The expectations (T0) for "seed thresher" UPS were closely similar in both regions. The average expected impact in T0 for Dodoma was 1.97, while in Morogoro the average expected impact was 2.04 (Table 9). Differences in all FSC existed, however there were no statistically significant differences in T0.

In contrast in T1 there was at least one significant difference in each sustainability dimension. Generally achieved impacts were lower for both regions; Morogoro was the worst performer with an average decline of 0.76 points compared to T0, Dodoma in change had an average decline of 0.38 point compared to T0. Significant differences were found for criterion: *food availability* (P≤0.05), *production* (P≤0.01) and *agrodiversity* (P≤0.05) (Table 9).

"Improved cooking stoves"

"Improved cooking stoves" had significant different regional expectations (T0). Dodoma had an average impact score of 1.09, while Morogoro had an average impact score of 0.39. Is interesting how the expectations of this UPS are considerably different, it seems that Morogoro did not believe the potential of this UPS. In fact the social dimension for Dodoma is significantly different for *food availability* (P≤0.05) *and social relations* (P≤0.001) (Table 9). Additionally the economic dimension, impact scores for *production* criteria are significantly different (P≤0.001) (Table 9); however this test did not fulfil the homogeneity of variance assumption.

Another interesting result is that none of the regions in T0 considered any relation between the UPS and the environmental dimension, the average score in this dimension for both regions was 0.15 for Dodoma and 0.3 for Morogoro (Table 9). On the other hand in T1 farmers seem to have changed this perception and recognized a relation between the UPS and the environmental dimension; the average score for T1 in Dodoma was 0.73 and in Morogoro 2.19.

Regarding T1 Morogoro results averaged 2.38 while Dodoma averaged 1.69. Morogoro dramatically increased its expected impacts by 1.99 points higher in average than in T0. In spite of that there were only significant differences for criteria: *food availability* (P≤0.05) and *available soil water* (P≤0.05) (Table 9).

Improved storage bags

In T0 improved storage bags was only active in Ilakala. No comparison was possible.

In T1 this UPS was active in both regions. The impact assessment results were similar for both regions; Dodoma averaged 1.48 while Morogoro averaged 1.38 points. This similarity may be a consequence of the early stages of implementation of this UPS (see Table 9). The only significant difference (P≤0.05) was in available *soil water* criterion; however this test did not fulfil the homogeneity of variance assumption (Table 9).

Sustainability Dimension	Food Security Criteria	Natural Resources				Kitchen Garden				Seed thresher				Improved cooking stove				Improved storage bags	
		Dodoma/Morogoro				Dodoma/Morogoro				Dodoma/Morogoro				Dodoma/Morogoro				Dodoma/Morogoro	
		t0	t0	t1	t1	t0	t0	t1	t1	t0	t0	t1	t1	t0	t0	t1	t1	t1	t1
SOC 1	Food availability	1.45***	2.52***	0.63***	1.78***	1.86	2.85	2.32	2.34	2.41	2.52	1.83*	1.29*	1.27*	0.31*	1.91*	2.29*	1.56	1.64
SOC 2	Social relations	1.70	2.48	1.77	2.13	2.46	2.76	2.69**	1.58**	2.27	2.20	2.33	1.84	2.09***	0.38***	2.73	2.71	1.42	1.57
SOC 3	Working conditions	1.92	2.38	1.45	0.98	1.75	2.25	2.24***	1.24***	2.47	2.33	1.33	1.86	0.27	0.23	2.45	2.71	1.72	2.14
ECO 1	Production	2.05	2.93	1.13	2.02	2.11	2.90	2.28*	1.66*	2.23	2.07	2.44**	1.69**	1.82***a	0.15***a	2.09	2.71	1.31	1.50
ECO 2	Income	1.89	2.74	0.82	1.53	2.38	2.90	2.31**	1.48**	2.07	1.97	1.69	1.79	1.91	0.38	2.18	2.43	1.36	1.50
ECO 3	Market participation	2.03	1.76	1.32	1.48	2.57	2.75	2.22**	0.79**	2.44	2.67	1.47	1.81	2.00	2.00	1.64	2.00	1.50	1.79
ENV 1	Soil fertility	2.64	2.74	1.99	1.92	0.65	1.20	2.29***	0.17***	1.20	1.59	0.94	0.31	0.00	0.00	1.00	1.71	1.56	0.86
ENV 2	Available soil water	2.64	2.74	2.07	2.28	0.68	1.20	1.98***	(-0.37)***	0.54	1.40	0.74	0.00	0.00	0.00	0*	2.29*	1.19*a	0.29*a
ENV 3	Agrodiversity	1.58	2.75	2.31	2.48	0.93	1.05	2.36	1.87	2.06	1.66	1.50*	0.93*	0.45	0.08	1.18	2.57	1.69	1.14

Table 9 Comparison between regions. * Criteria with a significant difference (α≤0.05). ** Criteria with a significant difference (α≤0.01). * Criteria with a significant difference (α≤0.001). a=did not fulfill the homogeneity of variance test. t0=FoPIA 1. t1= FoPIA 2.**

5.3. Comparing FoPIA 1 and FoPIA 2: Across villages comparison

In this section the results of the comparison across all villages are presented. The first part consists of a Kruskal Wallis test (KWt) across all villages for each upgrading strategy (UPS). This comparison uses the impact scores of the food security criteria (FSC) for a UPS in the same period (T0 and T1) and compares them across all villages to find out if there is at least one significant difference.

The second part starts consists of a post hoc test, using a Mann Whitney U test (MWUt) pair wise comparison, to locate the difference between the villages. If the UPS was only active in one village no comparison will be performed. The following UPS were analyzed: “rain water harvesting and micro fertilizing” (RWH/MF), “kitchen garden”, “sunflower oil pressing”, “seed thresher” and “improved storage bags”.

Testing across all villages (Kruskal Wallis test)

The first comparison was done across all villages at the same time. Table 10presents the significance values for the test. The nature of the hypothesis[2] of this test combined with the particular characteristics of the villages makes it likely that at least between two villages there are significant differences, thus rejecting the null hypothesis of equality of impact scores medians. Following the review of each UPS test results will be presented.

Rain water harvesting and micro fertilizing

Regarding RWH/MF in T0, the KWt showed that all FSC but *soil fertility* and *agrodiversity*, have at least one village with significant different scores (Table 10). These differences are highly significant (P≤0.001). This result means that the expectations of the UPS is not common across the villages, some farmers depending the village expect different impacts. However this characteristic is less strong in T1.

In T1 social and environmental dimension still showed generally significant differences between villages: *food availability* (P≤0.001), *working conditions*

[2]In the Kruskal Wallis test the alternative hypothesis assumes that there is a difference between at least two of the groups (Bewick et al. 2004, p. 196) in this case villages.

(P≤0.01), *soil fertility* (P≤0.01), and *available soil water* (P≤0.01) (Table 10). On the other hand in the economic dimension with the exception of *production* (P≤0.01), all villages had similar results across. This result indicates that impact assessment results for the economic dimension are similar for income and market participation across all villages.

"Kitchen garden"

Regarding UPS "kitchen garden" the expected impact in T0 for the economic dimension was shared across the villages, no significant differences were found. On the other hand, social and environmental dimensions showed significant differences in criterions *social relations* (P≤0.05), *working conditions* (P≤0.01), *soil fertility* (P≤0.001) *and available soil water* (P≤0.01) (Table 10). Differences in environmental dimension for this UPS are expected because the different climatic conditions of Dodoma and Morogoro.

Differences in T1 increased; at this period the economic dimension showed significant differences for criteria *income* (P≤0.05) and *market participation* (P≤0.01). Regarding the social and environmental dimensions, the differences present in T0 are continued in T1; whit the exception of *food availability, production* and *agrodiversity*, *social relations* (P≤0.05), *working conditions* (P≤0.01), *soil fertility* (P≤0.001) *and available soil water* (P≤0.001) (Table 10) showed significant differences.

"Seed thresher"

The case of "seed thresher" is interesting. The expectations in T0 of this UPS seem quite similar across the four villages, that is the villages expected in average the same impact of the UPS in the FSC. Only the criteria *available soil water* had significant differences (P≤0.001) (Table 10).

This characteristic is completely reversed for T1 impacts. In T1 the only FSC that do not have significant differences are *social relations* and *available soil water*; the rest of FSC are significantly different: *food availability* (P≤0.01), *working conditions* (P≤0.01), *production* (P≤0.001), *income* (P≤0.01), *market participation* (P≤0.05), s*oil fertility* (P≤0.01) and *agrodiversity* (P≤0.001) (Table 10)

"Improved cooking stove"

The test for "improved cooking stove" was only performed for T1. The results are quite different among the villages. This is confirmed by the test, consequently with the exception of agrodiversity, the rest of FSC had significant differences: *food availability* (P≤0.05)*, social relations* (P≤0.001)*,working conditions* (P≤0.001)*, production* (P≤0.01)*, income* (P≤0.01)*, market participation* (P≤0.05)*, soil fertility* (P≤0.01)*, available soil water* (P≤0.001) (Table 10).

"Improved storage bags"

Similar to the last UPS, the test for "improved storage bags" was only performed for T1. The achieved results are different among the villages. This is confirmed by the test. All FSC showed significant differences: *food availability* (P≤0.01)*, social relations* (P≤0.05)*,working conditions* (P≤0.01)*, production* (P≤0.05)*, income* (P≤0.01)*, market participation* (P≤0.001)*, soil fertility* (P≤0.001)*, available soil water* (P≤0.01), *agrodiversity* (P≤0.001) (Table 10).

"Sunflower oil pressing"

For the UPS "sunflower oil pressing" only the villages Idifu and Ilolo implemented this strategy. Since there are only two villages, the test is similar to the Mann Whitney U test. The expectations in T0 were not similar. The economic dimension had the most significant differences particularly for *production* (P≤0.05)*, income* (P≤0.05) (Table 10). Additionally there were significant differences in criterion social relations (P≤0.05) and available soil water (P≤0.001) (Table 10).

For T1 the differences increased; all environmental criterions had significant differences: *soil fertility* (P≤0.05)*, available soil water* (P≤0.05) and *agrodiversity* (P≤0.05) (Table 10). Regarding the economic dimension, *production* had similar results across all villages, but significant differences were found for *income* (P≤0.05) and *market participation* (P≤0.05). Additionally *food availability* showed significant differences (P≤0.01) (Table 10).

Sustainability Dimension	Food Security Criteria	RWH/MF		Kitchen Garden		Seed thresher		Improved cooking stove		Improved storage bags		Sunflower Oil Pressing	
		Idifu/Changarawe/Ilolo/Ilakala										Idifu/Ilolo	
		t0	t1	t0	t1	t0	t1	t0	t1	t0	t1	t0	t1
SOC 1	Food availability	0.000	0.000	0.174	0.272	0.981	0.004	.	0.016	.	0.007	0.489	0.004
SOC 2	Social relations	0.000	0.452	0.035	0.044	0.605	0.081	.	0.000	.	0.018	0.041	0.073
SOC 3	Working conditions	0.000	0.002	0.009	0.003	0.252	0.002	.	0.000	.	0.003	0.108	0.073
ECO 1	Production	0.000	0.003	0.215	0.064	0.500	0.000	.	0.002	.	0.040	0.019	0.116
ECO 2	Income	0.000	0.058	0.190	0.044	0.708	0.002	.	0.002	.	0.002	0.048	0.014
ECO 3	Market participation	0.000	0.087	0.590	0.010	0.586	0.024	.	0.032	.	0.000	0.145	0.014
ENV 1	Soil fertility	0.433	0.002	0.001	0.000	0.099	0.026	.	0.009	.	0.001	0.079	0.015
ENV 2	Available soil water	0.000	0.002	0.002	0.000	0.000	0.123	.	0.001	.	0.004	0.000	0.028
ENV 3	Agrodiversity	0.062	0.639	0.314	0.171	0.125	0.000	.	0.623	.	0.000	0.210	0.035

Table 10 Comparison across villages, Kruskal Wallis test.t0=FoPIA 1. t1=FoPIA 2. Numbers are the significant value of the test. Highlighted cells are criteria with a significant difference (at least α≤0.05).

Pair-wise testing between villages (Post hoc test)

The Kruskal Wallis test did not indicate any information on the village specific location of significant differences. Therefore in order to find them, a post hoc test was performed using a Mann Whitney U test pair wise comparison. For ease of presentation, the results of the pair wise comparison are presented for all FSC. An important reminder is the alpha level for this test. Since there were four villages and six combinations are possible, in order to take in to account the family wise error, the significance level was 0.05/6 (0.008333).

"Kitchen Garden"

The T0 expectations for UPS "kitchen garden" were generally similar across all villages. In the economic dimension, no significant differences were found, that means that all villages had shared economic expectations for this UPS. Changarawe showed many significant differences with other villages, these differences existed for both assessment periods. Changarawe not only had differences within the region (Morogoro) but also those differences existed with Dodoma.

The T0 expectations of *working conditions* criteria had significant differences between Idifu and Changarawe (P≤0.05/6), and Ilakala and Changarawe

(P≤0.05/6). Additionally, the environmental dimension showed significant differences; those differences existed for *soil fertility* between Idifu and Ilakala (P≤0.05/6), and Ilakala and Changarawe (P≤0.05/6); for *available soil water* significant differences were found for Idifu and Changarawe (P≤0.05/6), Ilakala and Changarawe (P≤0.05/6) (Table 11).

Regarding T1 impacts more differences compared to T0 were found. In the economic dimension, significant differences (P≤0.05/6) were found between Ilolo and Changarawe for criteria *production* and *market participation*. Additionally significant differences appeared in the environmental dimension, the highest of those (P≤0.001) been for *available soil water* between Changarawe and the pair comparison with Idifu, Ilolo and Ilakala (Table 11).

KitchenGarden	t	Food availability	Social relations	Working conditions	Production	Income	Market participation	Soil fertility	Available soil water	Agrodiversity
Idifu/Ilolo	t0	0.730	0.064	0.137	0.162a	0.16a	0.393	0.167	0.152	0.269a
Idifu/Ilakala		0.14a	0.018a	0.245a	1	0.165a	0.712	0.004	1	0.292a
Idifu/Changarawe		0.064a	0.031	0.006a	0.884	0.058a	0.173a	0.582a	0.000a	0.269a
Ilolo/Ilakala		0.22a	0.563	0.069	0.157a	1	0.758	0.018	0.175	1
Ilolo/Changarawe		0.117a	0.884	0.148a	0.107a	0.509	0.544	0.069a	0.013a	1
Ilakala/Changarawe		0.890	0.643	0.003a	0.890	0.486	0.418	0.000a	0.001a	1
Idifu/Ilolo	t1	0.073	0.493	0.265a	0.216a	0.705	0.863	0.245a	0.149a	0.226a
Idifu/Ilakala		0.719	0.016a	0.085a	0.648a	0.199	0.395	0.004	0.430	0.596
Idifu/Changarawe		0.458	0.028a	0.271a	0.599a	0.078	0.010	0.000	0.000	0.461
Ilolo/Ilakala		0.116	0.110	0.000	0.021	0.044	0.179	0.073	0.011	0.049
Ilolo/Changarawe		0.208	0.125	0.002	0.004	0.011	0.004	0.001	0.000	0.029
Ilakala/Changarawe		0.655	0.896	0.143	0.486	0.303	0.012	0.010	0.000	0.965

Table 11 Post hoc test, Kitchen garden. t0=FoPIA 1. t1=FoPIA 2. Numbers are the significant value of the test. a=did not fulfil the homogeneity of variance test. Highlighted cells are criteria with a significant difference (α≤0.05/6).

"Rain water harvesting and micro fertilizing"

The UPS RWH/MF had several significant differences in T0 (Table 12). Ilolo appears to have the most significant differences when compared with other villages. The social dimension shows the most significant differences, followed by economic. The highest of those differences (P≤0.001) were found when Idifu was compared to

Ilolo, Ilakala and Changarawe for *market participation.* This result means that the expectations for market participation with RWH/MF in Idifu were significantly higher (average of 2.83 see Table 5) in T0 than in the rest of the villages (Ilolo average of 1.23 see Table 6, Ilakala average of 1.83 see Table 7, Changarawe average of 1.68 see Table 8).

Regarding the scores for T1 the number of significant differences was lower. In this assessment period Changarawe has the most significant differences when compared with other villages. Interestingly the criterions *social relations, market participation* and *agrodiversity* had no significant differences, in spite of having differences in FoPIA 1. The highest significant differences (P≤0.001) were found in the social and economic dimension; for example when compared with the other villages Changarawe had the highest significant differences with Idifu and Ilolo for *food availability, production* and *income.* Regarding *income* Changarawe had significantly higher average (1.75 see Table 8) than Ilolo (average of 0.42 see Table 6).

RWH/MF	t	Food availability	Social relations	Working conditions	Production	Income	Market participation	Soil fertility	Available soil water	Agrodiversity
Idifu/Ilolo	t0	0.375 a	0.000	0.006	0.001	0.001	0.000	0.589	0.000	0.748
Idifu/Ilakala		0.000a	0.209a	0.373a	0.062a	0.641	0.004	0.108a	1	0.129
Idifu/Changarawe		0.081	0.008	0.050	0.216a	0.226	0.000	0.972	0.425	0.014a
Ilolo/Ilakala		0.001a	0.000a	0.000	0.000a	0.001a	0.144	0.254a	0.000a	0.214a
Ilolo/Changarawe		0.111a	0.011	0.248	0.001	0.003	0.184	0.676	0.000	0.039a
Ilakala/Changarawe		0.000a	0.002a	0.001	0.366	0.09a	0.700	0.161a	0.913	0.392
Idifu/Ilolo	t1	0.709	0.277 a	0.49a	0.007	0.14a	0.731	0.001	0.001	0.715
Idifu/Ilakala		0.024	0.901	0.448a	0.390	0.785	0.693	0.012	0.067	0.372
Idifu/Changarawe		0.000	0.697	0.004	0.656	0.832a	0.094	0.007	0.028	0.899
Ilolo/Ilakala		0.071	0.413	0.037	0.020	0.075a	0.376	0.116	0.008	0.612
Ilolo/Changarawe		0.001	0.085	0.011	0.001	0.001	0.066	0.334	0.048	0.500
Ilakala/Changarawe		0.027	0.548	0.002	0.160	0.776	0.011	0.559	0.458	0.176

Table 12 Post hoc test, RWH/MF. t0=FoPIA 1. t1=FoPIA 2. Numbers are the significant value of the test. a=did not fulfil the homogeneity of variance test. Highlighted cells are criteria with a significant difference (α≤0.05/6).

Seed thresher

This UPS had almost similar T0 expectations across all villages. The only exception was the *available soil water* criterion; Ilakala had significant higher score (average

score 2.33 see Table 7) (P≤0.001) when compared to Idifu and Changarawe (Table 13). The differences are related to the relation that farmers in Ilakala expected to have between this UPS and the FSC *available soil water,* whereas for Idifu and Changarawe the farmers saw only a minimal relation (Idifu average score 0.00 see Table 5, Changarawe average score 0.46 see Table 8).

In T1 there are significant differences in all sustainability dimensions (Table 13). The agrodiversity criterion had the most significant differences with the exception of Ilolo and Changarawe comparison. Social relations and market participation showed no significant differences. Idifu and Changarawe when compared to the other villages showed the most significant differences. For example for *agrodiversity* Idifu had significantly higher impact score (P≤0.001) (Table 13) (average of 3.00 see Table 5), whereas farmers in Changarawe did not saw any relation between this UPS and *agrodiversity* (average of 0.00 see Table 8).

Seed tresher	t	Food availability	Social relations	Working conditions	Production	Income	Market participation	Soil fertility	Available soil water	Agrodiversity
Idifu/Ilolo	t0	0.818	0.191	0.312	0.688	0.602	0.426	0.579	0.012a	0.281
Idifu/Ilakala		0.671	0.360	0.963	0.503	0.512	0.570	0.063	0.000a	0.663
Idifu/Changarawe		0.869	0.328	0.101	0.627	0.753	0.17a	0.873	0.183a	0.044
Ilolo/Ilakala		0.848	0.640	0.318	0.191	0.742	0.856	0.106	0.018	0.456
Ilolo/Changarawe		0.977	0.722	0.499	0.831	0.367	0.526	0.602	0.147a	0.215
Ilakala/Changarawe		0.802	0.906	0.112	0.175	0.322	0.459	0.015	0.001	0.054
Idifu/Ilolo	t1	0.009	0.299	0.003	0.117a	0.002	0.013	0.060	0.186	0.001
Idifu/Ilakala		0.019	0.401	0.484	0.159a	0.051a	0.606	0.054	0.587a	0.004a
Idifu/Changarawe		0.001	0.013	0.008	0.000a	0.003a	0.050	0.007a	0.52a	0.000
Ilolo/Ilakala		0.320	0.754	0.004a	0.596	0.023	0.018	0.631	0.05a	0.006a
Ilolo/Changarawe		1.000	0.379	0.237a	0.100	0.206	0.374	0.767	0.02a	1.000
Ilakala/Changarawe		0.218	0.115	0.014	0.002	0.077	0.083	0.727	1.000	0.000

Table 13 Post hoc test, Seed thresher. t0=FoPIA 1. t1=FoPIA 2. Numbers are the significant value of the test. a=did not fulfill the homogeneity of variance test. Highlighted cells are criteria with a significant difference (α≤0.05/6).

Sunflower oil press

This UPS was only active in Idifu and Ilolo. The T0 expectations among the villages were generally not equal; all sustainability dimensions had at least one significant difference (Table 14). The highest difference was in *available soil water* (P≤0.001) (Table 14), farmers had significantly higher scores because they did saw a relation

between this UPS and *available soil water* (average score 2.36 Table 5), whereas farmers in Ilolo did not saw any (average score 0.00 Table 6).

Impact assessments in T1 had several significant differences. The environmental dimension had significant differences in all FSC (P≤0.05) (Table 14). The economic dimension, with the exception of *production* criteria, had significant differences in *income* and *market participation* (P≤0.05) (Table 14). Regarding the social dimension, *food availability* had the highest significant difference (P≤0.01); farmers had significantly higher scores because in Idifu because they did saw a relation between this UPS and *food availability* (average score 2.33 Table 5), whereas farmers in Ilolo did not saw any (average score 0.00 Table 6).

Sunflower oil pressing	t	Food availability	Social relations	Working conditions	Production	Income	Market participation	Soil fertility	Available soil water	Agrodiversity
Idifu/Ilolo	t0	0.489	0.041	0.108	0.019	0.048	0.145	0.079	0.000	0.210
Idifu/Ilolo	t1	0.004	0.073	0.073	0.116	0.014	0.014	0.015	0.028	0.035

Table 14 Post hoc test, Sunflower oil press. t0=FoPIA 1. t1=FoPIA 2. Numbers are the significant value of the test. a=did not fulfill the homogeneity of variance test. Highlighted cells are criteria with a significant difference (α≤0.05).

Improved storage bags

This UPS was only analyzed for T1 period. The most significant differences were found for the economic and environmental dimensions. Interestingly the social dimension had significant differences (P≤0.05/6) (Table 15) only between Idifu and Ilolo for the criterions *food availability* and *working conditions*.

There is a trend of significant differences between Idifu and the rest of the villages. Those differences concentrate in the environmental dimension. For example, one of the highest differences is for *market participation* between Idifu and Ilakala (P≤0.001); Idifu had significantly higher scores (average of 3.00 Table 5) compared to Ilakala (average of 0.86 Table 7). This difference may be related to farmer's frustration with the price of bags (field notes see Table 17).

Additionally, production scores did not showed any significant differences in any pair wise comparison.

Improved storage bags	Food Availability Score t1	Social relations Score t1	Working conditions Score t1	Production Scores t1	Income Scores t1	Market participation Scores t1	Soil fertility Scores t1	Available soil water Scores t1	Agrodiversity Scores t1
Idifu/Ilolo	0.004	0.017	0.001	0.012	0.003	0.002	0.001	0.016	0.003
Idifu/Ilakala	0.035	0.024	0.028	0.099	0.001	0.000	0.004	0.005	0.000
Idifu/Changarawe	0.162	0.518	0.104	0.170	0.039	0.097	0.004	0.004	0.159
Ilolo/Ilakala	0.294	0.325	0.069	0.055	0.059	0.152	0.336	0.484	0.295
Ilolo/Changarawe	0.012	0.020	0.009	0.133	0.068	0.012	0.336	0.699	0.015
Ilakala/Changarawe	0.169	0.073	0.294	0.688	0.352	0.003	1000.000	0.656	0.002

Table 15 Post hoc test, improved storage bags. t0=FoPIA 1. t1=FoPIA 2. Numbers are the significant value of the test. a=did not fulfill the homogeneity of variance test. Highlighted cells are criteria with a significant difference (α≤0.05/6).

Improved cooking stoves

For T0 this UPS was only active in Idifu and Changarawe. T0 expectations were similar for the environmental dimension. On the other hand social and economic dimension had significant differences (P≤0.05/6), except for *working conditions* and *market participation* which had similar results.

For the T1 period results were generally similar (Table 16). Changarawe had the most significant differences when compared with the rest of villages. Significant differences (P≤0.05/6) were found only in *production* and *available soil water* criterions. Differences in *available soil water* were expected between Idifu and Changarawe since both are from different regions. The rest of FSC showed no significant differences in any of the pair wise comparisons.

The change in scores of Changarawe is interesting. Changarawe had an average increase from T0 to T1 of 1.99 points (see Table 8). This change in assessment was even significantly higher (P≤0.005, Table 16) than that of Ilolo by 1.71 (see Table 6, Table 8) points for *production* criteria.

Improved cooking stoves	t	Food availability	Social relations	Working conditions	Production	Income	Market participation	Soil fertility	Available soil water	Agrodiversity
Idifu/Ilolo	t0									
Idifu/Ilakala										
Idifu/Changarawe		.023a	0.001	0.849	.001a	0.002	0.462	1.000	1.000	0.340
Ilolo/Ilakala										
Ilolo/Changarawe										
Ilakala/Changarawe										
Idifu/Ilolo	t1	0.205	.025a	0.805	0.035	0.094	0.218	0.693	0.182	0.568
Idifu/Ilakala		0.205	.158a	.135a	0.213	0.448	0.648	.240a	0.873	0.817
Idifu/Changarawe		0.499	0.318	0.607	0.291	0.523	0.328	0.276	0.002	0.066
Ilolo/Ilakala		0.023	0.214	.057a	0.453	0.278	0.436	.042a	0.216	0.564
Ilolo/Changarawe		0.109	0.190	0.429	0.005	0.034	0.086	0.209	0.020	0.032
Ilakala/Changarawe		0.378	0.740	.293a	0.041	0.172	0.194	0.025	0.003	0.022

Table 16 Post hoc test, improved cooking stoves. t0=FoPIA 1. t1=FoPIA 2. Numbers are the significant value of the test. a=did not fulfill the homogeneity of variance test. Highlighted cells are criteria with a significant difference (α≤0.05/6).

5.4. Household characteristics analysis results

This section will address the second research question. Changes in impact assessments from T0 to T1 might be due to several factors, determinants, context, political situations, climatic patterns etc. Some of these determinants are revealed in the focus group discussions. Further, impact arguments recorded during the discussions shed light in to the “inner stories” that produced these changes. Some of these determinants are partially discussed in the previous section. Additionally is expected that household characteristics might have an influence in impact score assessments.

The aim of this section is to investigate if household characteristics might have an influence in the differences in scores assigned to UPS. In order to attain this aim a cluster analysis will be performed. Once the participants in the UPS are clustered in different groups based on their household characteristics (cluster analysis), their scores are compared (Man Whitney U test or Kruskal Wallis test). This comparison will inform whether there is a relation between a cluster of household characteristics and a pattern of results. The comparison will be presented by time of analysis and UPS.

The variables where explained in the methodology section (section 5.2). Dichotomous variables will be depicted as 0 or 1. The presence of the condition will be represented by the number 1, and the absence with the number 0. For example, if the respondents reported that the household has “other occupation”, the value of this variable is 1. With respect to gender, 1 is for male, and 2 are for female.

“Byproduct for bioenergy”

The characterization of the cluster for T0 is presented in Table 18. The clustering variables are organized in order of predicting importance from top to bottom. The size of the cluster is depicted, as well as the medians for the variables. For this UPS in this period the highest relative importance for clustering is the political membership, followed by age and household head. The first cluster consists of household without political association, in their late 30’s and all male headed households. On the other hand, in cluster number two all households are members of a political association, considerably older and there is a mix of male and female households. In cluster number two, land tenure is not as secure as in the first cluster; there is only 66.7% that reported land security. It could be said that cluster one is the youngest, male headed, bigger household. Those are the characteristics that distinguish this cluster from one another.

Once the clusters are defined the next step is comparing the impact scores to assess differences. This procedure was performed with the Mann Whitney U test. Table 19 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

The characterization of the cluster for T1 is presented in Table 18. The clustering variables are organized in order of predicting importance from top to bottom. Sizes of cluster, as well as the medians for the household variables are presented for each cluster. For this UPS in this period, the highest relative importance for clustering is household head, followed by total food expenditure and assets value. The first cluster consists of all male households, relatively less expenditure in food,

double the assets than cluster number two. On the other hand, in cluster number two the households are female headed, spend more in food, and have half of assets than the first cluster. Additionally this cluster is more than 10 years older and almost double in size.

In order to assess significant differences in impact scores, a comparison between clusters was made. This procedure was performed with a Mann Whitney U test. Table 19 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

"Improved cooking stove"

The characterization of the cluster for FoPIA 1 is presented in Table 20. The clustering variables are organized in order of predicting importance from top to bottom. The size of the cluster is depicted, as well as the medians for the variables. For this UPS, in this period, the highest relative importance for clustering is the fertility of the plot now followed by political membership and other occupation. The first cluster consists of households with fertile lands, without political association, fully dedicated to agriculture activities and with comparatively the smallest plots. On the other hand, in cluster number two all households have no fertile lands, more than half are not members of a political association and more than half are fully engaged in agriculture. Cluster number three consists of households with fertile lands, all members of political association and all have a secondary occupation. Those are the characteristics that distinguish these clusters from one another.

With these three distinctive clusters, the next step is comparing the impact scores to assess significant differences. This procedure was performed with the Kruskal Wallis test. Table 22 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

The characterization of the cluster for T1 is presented in Table 21. The clustering variables are organized in order of predicting importance from top to bottom. Sizes of cluster, as well as the medians for the household variables are presented for each cluster. For this UPS in this period, the highest relative importance for clustering is household head, other occupation and political membership. The first cluster consists of primarily of all male households, fully engaged in agriculture and members of political association. On the other hand, in cluster number two households are composed primarily mostly by female headed households, more than half engaged in agriculture and more than half without political association. Cluster number three consists primarily of all male households, with a secondary activity and without political membership. Those are the characteristics that distinguish these clusters from one another.

In order to assess differences in impact scores, a comparison between clusters was made. This procedure was performed with a Kruskal Wallis test. Table 22 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

"Improved storage bags"

The characterization of the cluster for FoPIA 1 is presented in Table 23. The clustering variables are organized in order of predicting importance from top to bottom. The size of the cluster is depicted, as well as the medians for the variables. For this UPS, in this period, the highest relative importance for clustering is household head, followed by political membership, market distance and fertility of the plot now. The first cluster consists of all male households, without political association and relatively closer to the market. On the other hand, in cluster number two there are all female households, politically active, further away from the market.

With these two distinctive clusters, the next step is comparing the impact scores to assess differences. This procedure was performed with the Mann Whitney U test. Table 24 presents the descriptive statistics for food security criteria scores in each

cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

The characterization of the cluster for T1 is presented in Table 23. The clustering variables are organized in order of predicting importance from top to bottom. Sizes of cluster, as well as the medians for the household variables are presented for each cluster. For this UPS in this period, the highest relative importance for clustering is other occupation, political association, and perceived land security. The clustering process for this UPS in this period needed three clusters to be fairly defined. The first cluster consists of households that do not have a second income activity besides agriculture, are all members of political association, all have perceived land security, have a mix of fertility of plots and are all male headed households. The second cluster has no other occupation, no members of political association, almost all have land security, fertile lands and are composed by a mix of gender household heads. On the other hand, in cluster number three of all households have a second income activity, they do not belong to any political association, land security is an issue and all are male headed households.

In order to assess differences in impact scores, a comparison between clusters was made. This procedure was performed with a Kruskal Wallis test. Table 24 presents the descriptive statistics for food security criteria scores in each cluster. The test comparison only yielded significant differences between clusters for food security criteria *social relations*. In order to locate which clusters are significantly different from each other a pair wise comparison was performed (Mann Whitney U test). The results indicate that cluster 3 has significantly different results when compared with the other two clusters. However when the significance is adjusted to the family wise error, the only significant difference ($P \leq 0.05/3$) is between cluster 1 and 3; whit this adjustment the comparison of cluster 1 to 2 has no significant differences.

This result means that male headed household's which are entirely dedicated to agriculture, members of political association, with perceived land security and with a mix of fertility in their plots have significantly higher impact assessment scores

(mean 2.40 Table 24) compared to households that have a second income activity, they do not belong to any political association, land security is an issue and all are male headed households. Consequently is possible to say that the grater the vulnerability of the households (no political association and land security is a problem) the lower the impact assessment of “improved storage bags” on *social relations.*

“Kitchen garden”

The characterization of the cluster for FoPIA 1 is presented Table 25. The clustering variables are organized in order of predicting importance from top to bottom. The size of the cluster is depicted, as well as the medians for the variables. For this UPS, in this period, the highest relative importance for clustering is fertility of the plot, followed by other occupation and distance from market. In FoPIA 1 the cluster analysis was defined by 3 clusters. The first cluster consists of households with fertile lands, primarily dedicated to agriculture, close to the market and the oldest of clusters. Cluster number two consist of fertile lands where all households perform an additional occupation, are close to the market and the youngest respondents. On the other hand, in cluster number three all households reported unfertile lands, almost all households perform only agriculture and are close to the market.

With these three distinctive clusters, the next step is comparing the impact scores to assess differences. This procedure was performed with Kruskal Wallis test. Table 27 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

The characterization of the cluster for T1 is presented in Table 26. The clustering variables are organized in order of predicting importance from top to bottom. Sizes of cluster, as well as the medians for the household variables are presented for each cluster. For this UPS in this period, the highest relative importance for clustering is other occupation, household head, and education. Three clusters were defined. The first cluster consists of households primarily dedicated to agriculture,

almost all male headed households with seven years of school in average. In the second cluster, all households have other occupation, all are male headed, and more than ¾ have no political association. On the other hand, in cluster number three more than fifty percent have a second occupation, mostly all female headed, without any political association.

In order to assess differences in impact scores, a comparison between clusters was made. This procedure was performed with a Kruskal Wallis test. Table 27 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

"Rain water harvesting and micro fertilizing"

The characterization of the cluster for FoPIA 1 is presented in Table 28. The clustering variables are organized in order of predicting importance from top to bottom. The size of the cluster is depicted, as well as the medians for the variables. For this UPS, in this period, the highest relative importance for clustering is household head, followed by distance from market and plot size. In FoPIA 1 the cluster analysis was defined by 2 clusters. The first cluster consists of households mostly female headed, at a medium distance from the markets, with relatively the smallest plot sizes. Cluster number two consists of all male headed households, at a short distance from the market and relatively bigger plots.

With these two distinctive clusters, the next step is comparing the impact scores to assess differences. This procedure was performed with Mann Whitney U test. Table 29 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

The characterization of the cluster for FoPIA 2 is presented in Table 28. The clustering variables are organized in order of predicting importance from top to bottom. Sizes of cluster, as well as the medians for the household variables are

presented for each cluster. For this UPS in this period, the highest relative importance for clustering is household head, household size, and value of assets. Two clusters were defined. The first cluster consists of all female households, relatively small with lower assets value. On the other hand, cluster number two has all male headed a households, almost double in size than cluster one, and with a great difference in assets.

In order to assess differences in impact scores, a comparison between clusters was made. This procedure was performed with a Mann Whitney U test. Table 29 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

"Poultry integration"

The characterization of the cluster for FoPIA 1 is presented in Table 30. The clustering variables are organized in order of predicting importance from top to bottom. The size of the cluster is depicted, as well as the medians for the variables. For this UPS, in this period, the highest relative importance for clustering is other occupation, followed by distance from market and member of political association. In FoPIA 1 the cluster analysis was defined by 2 clusters. The first cluster consists of households with no other occupation, at a short distance from the market and more than half of them belong to a political association. Cluster number two consists of all households with other occupation, at a long distance from the market and without a political association.

With these two distinctive clusters, the next step is comparing the impact scores to assess differences. This procedure was performed with Mann Whitney U test. Table 31 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

The characterization of the cluster for FoPIA 2 is presented in Table 30. The clustering variables are organized in order of predicting importance from top to bottom. Sizes of cluster, as well as the medians for the household variables are presented for each cluster. For this UPS in this period, the highest relative importance for clustering is value assets, perceived land security, and market distance. Two clusters were defined. The first cluster consists of households with relatively less assets, no land security and far away from the markets. On the other hand, cluster number two has almost four times the assets, all households have some perceived land security, are at a medium distance from the market and all are male headed a households.

In order to assess differences in impact scores, a comparison between clusters was made. This procedure was performed with a Mann Whitney U test. Table 31 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

"Seed thresher"

The characterization of the cluster for FoPIA 1 is presented in Table 32. The clustering variables are organized in order of predicting importance from top to bottom. The size of the cluster is depicted, as well as the medians for the variables. For this UPS, in this period, the highest relative importance for clustering is other occupation, followed by household head and household size. In FoPIA 1 the cluster analysis was defined by 3 clusters. The first cluster consists of households with almost no other occupation, all male headed, with comparatively medium size households and a mix of fertility of land. Cluster number two consists of all households with ¾ no other occupation, mostly female headed, and the smallest in size comparatively. On the other hand, cluster number three is composed by households that have a second occupation, mostly male headed, the biggest in size and the youngest respondents.

With these three distinctive clusters, the next step is comparing the impact scores to assess differences. This procedure was performed with Kruskal Wallis test. Table 34 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

The characterization of the cluster for FoPIA 2 is presented in Table 33. The clustering variables are organized in order of predicting importance from top to bottom. Sizes of cluster, as well as the medians for the household variables are presented for each cluster. For this UPS in this period, the highest relative importance for clustering is membership to a political association, assets value, market distance and other occupation. Three clusters were defined. The first cluster consists of households with no political association, the highest on assets value, situated the furthest away from markets and having other occupation. On the other hand, cluster number two has almost all households members of political association, they are the second in assets value, situated at a short distance to the market and more than two thirds only do agriculture. Cluster number three is composed by households with almost no political associations, the lowest in assets value, situated at a short distance to the market and entirely dedicated to agriculture.

In order to assess differences in impact scores, a comparison between clusters was made. This procedure was performed with a Kruskal Wallis test. Table 34 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

“Sunflower oil pressing”

The characterization of the cluster for FoPIA 1 is presented in Table 35. The clustering variables are organized in order of predicting importance from top to bottom. The size of the cluster is depicted, as well as the medians for the variables.

For this UPS, in this period, the highest relative importance for clustering is fertility of the plot followed by household head and plot size. In FoPIA 1 the cluster analysis was defined by 3 clusters. The first cluster consists of households with no perceived fertility, all female headed, with medium size plots and at a medium distance from the market. Cluster number two consists of households with fertile plots, mostly female headed, and the smallest in size comparatively. On the other hand, cluster number three is composed by households that have fertile plots, male headed, the biggest in size and short distance to market.

With these three distinctive clusters, the next step is comparing the impact scores to assess differences. This procedure was performed with Kruskal Wallis test. Table 36 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

The characterization of the cluster for FoPIA 2 is presented in Table 35. The clustering variables are organized in order of predicting importance from top to bottom. Sizes of cluster, as well as the medians for the household variables are presented for each cluster. For this UPS in this period, the highest relative importance for clustering is other occupation followed by perceived land security and age of respondent. The first cluster consists of households with other occupation, no land security, and the biggest plots. Cluster number two is composed by households with almost no other occupation, land security, relatively younger and with the smallest plot sizes.

In order to assess differences in impact scores, a comparison between clusters was made. This procedure was performed with a Mann Whitney U test. Table 36 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

“Tree Planting”

The characterization of the cluster for FoPIA 1 is presented in Table 37. The clustering variables are organized in order of predicting importance from top to bottom. The size of the cluster is depicted, as well as the medians for the variables. For this UPS, in this period, the highest relative importance for clustering is other occupation followed by fertility of the plot and land security. In FoPIA 1 the cluster analysis was defined by 2 clusters. The first cluster consists of households with other occupation, almost all with perceived fertility, all with land security and the smallest plots. Cluster number two consists of households with no other occupation, not fertile plots, with mix land security and the biggest plots.

With these two distinctive clusters, the next step is comparing the impact scores to assess differences. This procedure was performed with Kruskal Wallis test. Table 38 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters.

The characterization of the cluster for FoPIA 2 is presented in Table 37. The clustering variables are organized in order of predicting importance from top to bottom. Sizes of cluster, as well as the medians for the household variables are presented for each cluster. For this UPS in this period, the highest relative importance for clustering is food expenditure followed by political association and value assets. The first cluster consists of households with comparatively smallest food expenditure, no political associations, the smallest assets value and no other occupation. Cluster number two is composed by households with the biggest food expenditures, all members of political associations, the biggest assets value and half of them have another occupation.

In order to assess differences in impact scores, a comparison between clusters was made. This procedure was performed with a Mann Whitney U test. Table 38 presents the descriptive statistics for food security criteria scores in each cluster. Even though score differences existed between clusters in all FSC, the comparison

of their scores did not yield enough evidence to suggest a significant difference between household clusters.

6. Discussion

6.1. FoPIA 1 and FoPIA 2 assessments comparison

The analysis performed in section 6.1 to 6.3 presented the results of the comparisons between FoPIA 1 and FoPIA 2 at three levels: 1) within village, 2) between regions, and 3) across villages. These results answered the research question (Rq1) regarding possible assessment differences between the two periods. The analysis performed confirmed significant differences between ex-ante (T0) assessments and ex-post (T1) assessments of the impacts of upgrading strategies (UPS) on different food security criteria (FSC) across the three levels of comparison.

Regarding within village level comparisons, significant differences were found in particular for UPS a) ”improved storage bags” that had an average difference for all FSC of 1.49 points lower compared to T0, although this result reflects only Ilakala where the UPS was active in both periods (Table 7).b) “poultry integration” which had an assessment on average for all FSC 0.91 points lower than T0, however only Changarawe implemented this UPS(Table 8). c) “rain water harvesting and micro fertilizing” (RWH/MF), were the impact assessment was 0.60 points lower in average for all FSC compared to T0 (Table 5, Table 6, Table 7, Table 8). And finally d) “improved cooking stoves” where an average increase of 1.29 was found for all FSC compared to T0. This result is considerably influenced by the assessments in Changarawe that were in average 1.99 points higher for all FSC compared to T0 (Table 5, Table 6, Table 7, Table 8).

At the regional level significant differences were also found. The expectations (T0) of all UPS were generally shared and similar between regions, with the exception of “improved coking stove”, were Dodoma had significantly higher expectations in the

social dimension (Table 9). On the other hand, assessments in T1 showed significant differences particularly for “kitchen garden,” were Dodoma had in average more than 1.0 points higher for all FSC than Morogoro (Table 9).

The comparison across village level evidenced significant different impact assessments for T0 and for T1. Interestingly “seed thresher” in T0 had similar assessments across all villages in all FSC but *available soil water (*P≤0.001 Table 10*),* this may be attributable to the different climatic conditions of Dodoma and Morogoro. Additionally, this comparison allowed locating village to village differences of impact assessments. Regarding T0 assessments, significant differences were found particularly for RWH&MF, where for example Idifu (average score 2.83 Table 5) had highly significantly different scores (P≤0.001) (Table 12) for FSC *market participation* with village with Ilolo (average score 1.23 Table 6) and Changarawe (average score 1.68 Table 8). Farmers in Idifu are comparatively further away from regional markets, thus is possible that they expected (T0) to get the most benefits from market participation.

On the other hand, T1 assessments showed that Changarawe had the highest presence of significant differences when compared to other villages particularly for UPS “kitchen garden” (Table 11) and RWH&MF (Table 12). For example UPS “kitchen garden” in FSC *soil fertility* had highly significant differences (P≤0.001) (Table 11). This result reflects the differences in perception that the villages had regarding the interactions between the UPS and FSC, in this particular case *soil fertility*; Changarawe had an average T1 score of -0.67 (Table 8) whereas Idifu 2.58 (Table 5), Ilolo 2.00 (Table 6) and Ilakala 1.00 (Table 7). Additionally for T1, Idifu had several highly significant differences (P≤0.001) for UPS “seed thresher” (Table 13) and “improved storage bags” (Table 15) particularly for FSC *agrodiversity*.

The differences found on the statistical tests can be partially explained through the analysis of impact arguments and also the implementation status. Furthermore, an examination of household characteristics helped to discern potential differences in

impact scores based on different clusters of farmers (section 7.2). In the following these causes of differences are discussed.

The analysis of the impact arguments showed that they are important elements in the explanation of differences in impact scores. The impact arguments provide a contextualized understanding of differences in scores. This contextualization provides the "story lines" (König et al. 2010, p. 2006) behind differences in scores. The story lines point to arguments related to four elements: 1) weather related problems, 2) social issues, 3) managerial performance, and 4) work load related issues.

1) Between the first and the second assessment there were "weather related problems" in the four CSS. Those problems affected the development, implementation and potential impact of some UPS, especially those related to the natural resources. Tanzania during the 2015 rainy season experienced a 4 to 6 weeks dry spell. Thus, any possibly achieved positive impacts of UPS were constrained by this effect. For example farmers commented that crop yields and survival of planted seedlings was low, therefore it was difficult to assess the effectiveness of the UPS (Table 17, and field notes).
2) The implementation of some UPS more or less affects the fabric of "social relations" in the community. For example some farmers commented on changes of traditional knowledge and practices and of jealousy between participants and not participants for funds allocation (Table 17, and field notes). These problems negatively affected the social relations. Were evidence of these problems was already manifested in the first assessment period (Schindler et al. 2016, p. 58), farmers still manifested their concern in the second assessment period.
3) Regarding the "managerial performance" there was evidence of problems that affected assessment impact scores. Although these problems are not related to the nature and potential of the UPS, they definitely influenced changes from expectations and the impact perceived by the farmers. Those managerial issues for instance are related to practical issues such as misunderstandings between staff and farmers about the management of

baby plots, or, another example, moving the seed thresher in Ilakala. Transfer of know-how in some cases was difficult, for example, farmers commented that the knowledge required for spacing and making tied ridges was critical. The price of storage bags was underestimated, and the oil press in Ilolo was found to be not economically feasible. (Table 17, and field notes).

4) Farmers initially underestimated work load needed for implementation, thus generating differences between the two assessment periods. In the first assessment period there were expectations that the UPS will reduce work load and increase efficiency of production process, for example with the use of “seed thresher”, “improved cooking stoves” or RWH/MF. However the underestimation of work load generated frustration and a lower than expected score (Table 17); for instance in Changarawe UPS RWH/MF expected impact (T0) for FSC *working conditions* was 1.86, whereas in T1 the score was -0.25 a highly significant decrease ($\alpha \leq 0.001$) (Table 8).

The analysis of this thesis is a midterm evaluation; therefore differences in scores can also be traced back to the implementation status. There is a time lag between implementation and observable effects of an UPS (or innovation). This difference creates problems for evaluation since some benefits of adoption or implementation may only manifest after this evaluation was conducted. As highlighted by LILJA, DIXON(2008, p. 9) if the ex-post evaluation is conducted at early or mid-stages of adoption only a portion of the ultimate benefits is observable. Some of the UPS although implemented had just been active for some months while others just had started or faced difficulties. Some of these factors created frustration among farmers, that when asked about the impact of the UPS in FoPIA 2, indicated being negatively influenced by this time lag between implementation and fully fledged running UPS (Table 17 and field notes).

Generally, an overall decline was found among stakeholder from an overly optimistic expectation to a more sober reality. Lower than expected impact scores were the combination of over expectations, the four elements mentioned above plus the implementation status in some cases such as ”seed thresher”, “sunflower oil

press", "improved storage bags" and "poultry integration"(Table 17, field notes and see Table 5, Table 6, Table 7, Table 8).

6.2. Household characteristics analysis

After analysing impact arguments and implementation status, the analysis of differences in scores between FoPIA 1 and 2 moved towards inclusion of household characteristics. It was hypothesized that a pattern could exist between household characteristics and impact scores. Even though differences existed between clusters in all UPS (T0 and T1), the comparison of their scores did not yield enough evidence to suggest a significant difference between household clusters (see for example Table 29).

Household characteristics are determinant of different food security status and adoption of strategies (Babatunde, Qaim 2009; Mutabazi et al. 2015; Tesfaye et al. 2011; Petrovici, Gorton 2005; Mason et al. 2015), thus is conceivable that household characteristics influence the impact assessment of UPS on food security. For example households with bigger plots might experience a bigger effect of tied ridges, or households with more family members could experience a stronger effect of implementing kitchen gardens. However the comparison of clusters did not yield sufficient evidence for a relation between household characteristics and impact scores on FSC.

Three explanations can be suggested. Firstly, the implementation of UPS has not yet mature to show significant differences between clusters. However, there are UPS such as RWH/MF, "tree planting", and "improved cooking stoves" that had longer duration. Secondly, and more radical, it is possible that, due to the subjective-qualitative nature of the assessment (perceived impact, scores and scale) the stakeholders tend to have an overall *shared perception,* even between heterogeneous household clusters. In brief, is possible that the evaluation is too subjective to lead to valid comparisons among households clusters. This possible imprecision may translate into problems of targeting, program management, monitoring and midterm evaluation. Thirdly, but less likely it is possible that there is

no relation between impact scores and clusters of households. More research is needed to discern from these three possibilities.

Additional insights

Another interesting point discovered in the analysis was the changes in perceptions regarding the relation of UPS impacts and food security criteria (FSC). The changing perception is manifested by a change in the spread of impact scores, were three different score movements where identified (Figure 10 to Figure 17 for visual comparison).

The spread of the impact results is a signal of the complex interrelations of a UPS and a FSC. The impact of a UPS may have direct and indirect consequences; and the positive and negative assessments evidence the holistic approach that farmers have regarding the interrelations of UPS and a FSC. Schindler et al.(2016) and Schindler(2016) confirmed the holistic view of farmers towards the local food security context. This is also evidenced in the ex post assessment performed here. Farmer's comments (field notes) and scorings (the spread of results) confirmed the interlinkages between UPS and different sustainability dimensions and food security criteria. However the findings are not uniform, three different moves where identified by comparing FoPIA 2 with FoPIA 1.

Firstly, farmers scored lower and/or the spread of results increased compared to FoPIA 1. For example impacts of RWH/MF on *working conditions* in Changarawe (Figure 16, Figure 17, Table 8). In this case the expectations (T0) were high with a median of 2 points and a range from 0.5 to 3 points; in the other hand in T1 the median is 0 and the range goes from -2 to 2. Farmers reported that lack of experience was troublesome for building the tied ridges; additionally managing the proper spacing for maize intercropping was difficult, these difficulties can explain the change in perception.

Secondly, farmers that saw a relation in FoPIA 1 they did not see it during the FoPIA 2 mission. For example the environmental dimension in Ilakala for UPS "improved storage bags" (Table 7,Figure 14, Figure 15). In this case farmers made no further comments regarding the relation between environmental dimension and the

UPS, however the price of the bags was perceived to expensive and farmers got frustrated (Table 17).

Thirdly, farmers that did not saw a relation in FoPIA 1, later in FoPIA 2 they see it. For example, *available soil water* for UPS "improved cooking stove" in Changarawe. Farmers saw no relation between the UPS and the criterion in T0 (average score 0.00) whereas, in T1 impact score is 2.29 (Table 8, Figure 16, Figure 17). Farmers commented that the time saved for cooking allows them to allocate surplus time to other productive activities (field notes).

These three movements are highly relevant because they might inform an underlying *changing perception* of the potential impact of UPS over time. The analysis of the spread is as important as a change in median scores (Hart 2001). Therefore even if the impact scores may have not showed significant differences, a change in spread (distribution) is important.

Generally, the scores in FoPIA 1 are highly concentrated in the positive range around the +3 score, whereas for FoPIA 2 there is a decrease in medians (and means) towards the +2 score, but importantly the spread of results increased, particularly for improved cooking stoves, improved storage bags, kitchen garden and RWH/MF (Figure 10 to Figure 17). The increment in negative score frequencies should be a warning sign-tool for the present and future UPS implementations.

A closer look in to the "history lines" behind the change in perceptions brought another rather interesting point. During FoPIA 2 it was common among farmers to mention that, the profits gained from one UPS could be used to buy inputs (e.g. fertilizer) thus, for example, increase soil fertility. The point is then that, a UPS relation to different FSC seems to be narrowed down to a market relation, where the profits from a UPS could be used to increase the impact in a FSC. Following this example it could be said that the soil fertility may be bought. Consequently the question is why? And does this represent a risk?

As described above there were three different changes in perceptions; one of those is when farmers saw a relation and later they don't. In this case something

happened during the implementation or during the focus group discussion that caused the change in perception. There are two possibilities. First, that the implementations make the farmers realize that there is no relation, therefore the changing perceptions; or second, and the point of this discussion, that the farmers arrived to this conclusion during the focus group discussion. Why?

In the focus group discussion the "communicative-rational" approach involved in the process of discursive analysis creates the conditions for social learning within the participants of the workshop (Morris et al. 2011, p. 4) and the scientists (Schindler 2016).This social learning set the scene for a symbiosis of knowledge between scientist and farmers. The problem is that this symbiosis seems to have, in some cases, eroded the triple bottom line approach (Morris et al.2011, p. 14) and/or relegating to a more linear relation, market dependent thinking, the complexity between UPS impacts on FSC. As the farmers mentioned, soil fertility can be bought. The question then is: is this approach risky?

While the idea of improvement is commendable and should be promoted, the dependency created with an "exterior agent" for something as crucial such as soil fertility may be risky for vulnerable farmers as those in the case study sites. The risk lies in considering that positive impacts on the environmental dimension may be achieved majorly trough profits acquired in the market. The present situation of farmers in the CSS does not favour this logic. Morris et al.(2011, p. 14) emphasized that the FoPIA facilitates an integrated Triple Bottom Line approach, where economy, society, and environment are not independent from one another but complexly interrelated. Therefore there is a risk if these complex interrelations are narrowed down such that, for example, fertility can be acquired in the market.

Although there is a balanced mix between strictly market oriented and food producing-securing UPS, the analysis of this thesis highlighted the benefits of promoting UPS that enhance the sovereignty of farmers. The UPS that were directly related to market strategies, such like "seed thresher", "sunflower pressing machine" and "Improved storage bags" suffered the biggest decline in assessments (Figure 10 to Figure 17; and Table 5 to Table 8). Take for example the case of "seed

thresher" in Ilolo where a combination of issues like work load miscalculations, mechanical problems, no facilities to set the machine, droughts, low yields, etc. generated a frustration among farmers and a decline in impact assessments (Table 6, Table 17, Figure 12, Figure 13). On the other hand, strategies oriented to food producing-securing such like RWH/MF, "kitchen garden", "improved cooking stove", "tree planting" had a lower decline in assessments. The case of Changarawe is particularly interesting. This village is the closest to bigger markets and despite this there was an assessment decline of more than 1.0 points in average comparing T0 to T1 for "seed thresher", while "improved cooking stoves" had an average increase of close to two points (Table 8). This evidence suggest the important benefits of promoting UPS that do not rely directly on market benefits for impacts on FSC, and therefore do not have the same risk as the others.

FoPIA- critical reflection

The analysis performed in this thesis also resulted in a proposal for adjusting and/or improving the FoPIA methodology. The idea arises from two interrelated conclusions. First, the FoPIA as applied in the framework of FVC for the development of UPS for food security may fail to create a "common scenario" for *all* stakeholders. Second, distribution issues may be better addressed when a "common scenario" is built. The consideration of these two conclusions led to the proposal of integrating two more concepts: civic agriculture (Lev, Stevenson 2010; Lyson 2004) and nested markets (van der Ploeg, Jan Douwe et al. 2012) that may serve to enhance the design/selection of UPS for food security developed through the FoPIA methodology. In the next lines these ideas are developed.

The original developments of FoPIA provided the milieu for stakeholders with relative balanced influence to create common goal trough the development and evaluation of possible scenarios. Within the complexities of public administration, all stakeholders, namely policy makers, gov. officials, ministers, etc. had balanced power relations to influence the outcome, selection and evaluation of the possible scenarios; for example all affected parties of a new land use system were present and had their chance to push their views, to interact, consider relations between sustainability dimensions, assess policy impacts and discuss trade-offs and

compromises between scenarios (Morris et al. 2011). But this is may not be true when FoPIA is applied within the FVC framework for the development of UPS, and therefore possible scenarios.

The selection of UPS and their evaluation only involved scientist and local farmers. Scientist selected possible UPS for the case study sites (Uckert et al. submitted for publication) (Phase 2, step 1 Figure 8); later farmers trough FoPIA methodology evaluated and selected UPS for their local context (Schindler et al. 2016) (Phase 2, step 2 Figure 8). Local farmers, researchers and experts are not the entire spectrum of stakeholders affected by a UPS in a value chain; middlemen, traders, suppliers, manufacturers, logistic companies, warehouses, retailers, wholesalers, etc. are missing from the table of negotiations. Their absence is for detriment of the possible UPS-scenarios that could be built in cooperation.

Moreover since the use of a FVC approach aims to be systematic by considering all the links in the chain (Graef et al. 2014), from natural resources to consumer and back to natural resources trough waste management, it also miss in the table of negotiations the consumers (stakeholders) of products that are beyond the case study sites where the UPS were selected; also for the detriment of the possibilities that could be reach trough their inclusion. Leaving aside for the moment the competing interest of the links within a chain (see below), since not all stakeholders are involved in the process of evaluating and selecting UPS, the number and quality of possible scenarios that could be constructed decrease. Therefore no common ground, no trade-offs, no win-win scenarios could be established.

Riisgaard et al.(2010, p. 197) recognized that “Local-level action on its own,[...] will rarely suffice to promote significant change” because of the conflicting interest between stakeholders in the value chain. Therefore in a process of scenario building trough the selection of UPS were only the local farmers are involved, the expectations of success are limited. Farmers, especially those in the case study sites, are at the bottom of the pyramid and hold little bargaining power, institutional leverage and assets to push for better deals. Therefore the selected UPS, and the consequent scenarios, are not a result of push and pulls between links in the value

chain. They are not a result of finding solutions that benefit all, but the scenarios built at the local level are what is possible to happen within their circumstances. The original purpose of FoPIA is to convene at negotiation table all stakeholders involved and to develop a "common scenario", while in a value chain analysis such as demonstrated here this is rather difficult[3].

The second conclusion that brought the idea of the proposal, and a key concept in value chain analysis, is the consideration of the distribution of benefits. Identification of the distribution of benefits among the FVC stakeholders is key to understand consequences and impacts of UPS (Kaplinsky, Morris 2001), and therefore serves as a platform for strategic planning (Isakson 2014). In this sense one way to enhance the positive impacts on distribution outcomes of UPS for food security is to coordinate the actions of all stakeholders trough the construction of common scenarios, such that the benefits reach the more vulnerable links.

The coordination of stakeholders refers inherently to the governance of the FVC. Inter-firm relations and institutional mechanisms which facilitate non-market coordination of activities set the frame for distribution outcomes (Humphrey, Schmitz 2001, p. 22). There is attempts of improving distribution outcomes by increasing the value added and the portion that returns to the farmers, those strategies are called pro poor value chains (ADB 2012; Mitchell et al. 2009; Poulton et al. 2006). Evidently the UPS implemented in Trans-SEC project, that follow the aim of improving the situation of the most-vulnerable poor population of Tanzania (Graef et al. 2014, p. 9), are considered pro-poor UPS for food security; and as evidenced in this thesis the income criteria of the UPS has a positive impact (see Table 5 to Table 8). Nevertheless the coordination/governance of links within the chain could be taken a step forward to improve distribution outcomes. This is the point of the proposal.

[3] Examples where negotiations exist between all links in the value chain exist, for example the Roundtable on Sustainable Palm Oil RSPO, however this is a global value chain and it is only for a single commodity. In the literature consulted for this thesis no examples were found where all links and all livelihood related activities were included in a value chain analysis.

There is no perfect technique for evaluation (Baker 2000, p. 2) and for selection of UPS. However, strategic and political approaches that favour disadvantaged groups should be considered (Riisgaard et al. 2010, p. 197). Further macroeconomic trends and determinants of social capital should be considered in order to have a "complete" analysis (Kaplinsky, Morris 2001, p. 6). For these reasons if the FoPIA is modified such that all stakeholders in the FVC are considered for the selection of UPS a common scenario could be built, therefore distribution outcomes could also be improved.

In this sense an approach that may serve vulnerable farmers in strategically designing "common scenarios" in conjunction with all stakeholders of the FVC is that of "civic agriculture" (Lyson 2004). In this way the distribution of value along the chain could be *built* starting from a process of negotiation that a FoPIA could facilitate. Lev, Stevenson(2010) develops this concept and applies it to value chain analysis. Civic agriculture in this way relies in collective action to construct something he calls a "third tier" of agricultural systems, referring to midsize farms and their strategic alliances building process, which may ensure competitiveness and survival. This concept is similar to the concept of "nested markets" developed by van der Ploeg, Jan Douwe et al.(2012). Summing up an improved pro-poor approach could be a "nested civic chain" that is built through a FoPIA process. Value chain analysis is not restricted to interventions targeted exclusively to producers, it should also have society-wise and chain-wise aims (Riisgaard et al. 2010, p. 202).

Lessons learned

The objective of this thesis was to analyze impacts of development strategies for food security implemented in Tanzania. This goal was attained trough the statistical comparison of impact assessment scores. Although the goal was reached, some lessons could be derived.

The subjectivity of the assessment may have had caused uncertainty among farmers when evaluating the impact of UPS. There is a price to pay in semi-quantitative assessment, and when the perceptions of an UPS impact are translated

to personal opinions, their comparison is problematic. As Baker (2000, p. 2) said there is no perfect technique in evaluation, thus this subjectivity is the price to pay to evaluate farmers opinion on UPS impact.

The use of likert scale measures makes it difficult to determine the distance between two points in the scale. The difference between two points in a likert scale is not measurable. Although there is an order in the scale, if a farmer assess with two points and another with three, the only thing possible to say is that one farmer assess is higher than the other, but what does that distance represents is not measurable.

Quality of data must be a priority when collecting information and results at the workshops. A great amount of time was spent cleaning and triangulating the data, this problem could have been easily solved. Especially when triangulating household data with focus group discussion the names of participants were recorded with small differences that make necessary to go one by one to find the misspells.

The analysis highlighted the importance of extensive qualitative field data to contextualize changes in impact scores. Although the methodology employed answered satisfactorily the research questions, the analysis performed highlighted the importance of soft qualitative data for midterm or ongoing projects. Much of the context in an ongoing or midterm project, were the effects are not yet present, will not be found essentially in the impact assessment scores but in the “story lines” shared in the focus group discussions. Much more emphasis should be devoted to the record of those story lines for future evaluations and especially for projects/UPS that are not yet completely implemented or finished.

7. Conclusions

Summing up, the analysis of FoPIA 1 and 2 assessments data from upgrading strategies (UPS) impacts on different food security criteria (FSC) yielded evidence of significant differences between the two assessment periods. The methodology implemented allowed to statistically confirm those differences in impact

assessments; as well as to explain and contextualize the differences. Additionally the analysis of household characteristics although provided evidence of differences between households scores, the evidence was not significant.

The results compiled in this thesis showed that:

- The impact of UPS is still high. Although an overall assessment decline from ex-ante expectations occurred, the impact of UPS on food security is still expected to be high.
- Managerial and climate related shocks negatively affect farmer's perceptions of UPS impact. Nevertheless is considered that if theoretically all managerial issues and climate related shocks would not have been present the potential positive impact of UPS is still high.
- Impact arguments and implementation status are essential to understand changes in impact scores for midterm impact evaluation efforts.

Further analysis is recommended to the development and adjustment of UPS particularly for Changarawe village which had the most significant negative assessment changes compared with the other villages. Some lessons could be derived from Idifu since this village had relatively more conservative expectations which were similar to its Fopia 2 results. In this sense the results of this thesis could be used as to inform for prioritization of follow-up implementation efforts.

Another area for further analysis could be the comparison of the stakeholder-based assessment results with those of scientists. A similar analysis was developed already by Schindler(2016) for FoPIA 1.

On the whole the results of this thesis may be used for re-aligning research activities because it highlights unexpected changes in perceptions; provides information for management decision; and provides evidence of achieved results. Therefore it may be used for prioritization of investment and accountability, and it also may serve for institutional learning.

The analysis of the change in impacts of UPS in ongoing projects is critical to understand why they fail or succeed and a precondition to up-scaling of UPS. This

thesis addressed this issue, thus it provides a step forward for making food securing UPS implementations more efficient and ultimately enhancing the project success.

8. Summary

The overall aim of this thesis was to analyze and evaluate the impact scores of two impact assessment missions (FoPIA) carried out in 2014 and 2015 in four rural villages of Tanzania. The assessments evaluated the impact ex-ante and ex-post of nine food securing upgrading strategies (UPS) implemented as part of a large international research and development project. There were two main research questions in this thesis: 1) exploring and comparing impact assessments scores of the two assessment periods; and 2) exploring the possible causes of differences, with a special emphasis on impact arguments, implementation status and household characteristics.

In order to answer the first research question three statistical tests were carried out: differences between ex-ante and ex-post assessment results within each village, between regions, and across all villages. Complementing this, the implementation status and impact arguments were discussed. The second research question used a cluster analysis to examine whether different clusters of households had significant assessments differences in each assessment period.

The results of the first research question showed an overall scoring decline from FOPIA1 to FoPIA 2 with an average of 0.39 points lower. There were significant changes in all three statistical comparisons; within the villages, between regions and across villages. This showed that at the village level there were over optimistic expectations that were not meet for a combination of elements related to 1) weather related problems, 2) social issues, 3) managerial performance, and 4) work load. Also the implementation status of UPS was found to be related to the decline on impact assessment. The qualitative evidence provided from the impact arguments and implementation status was key to understand the story lines behind scores assessment differences.

Generally, Idifu village had the most sober expectations, while Changarawe registered the most significant changes. At the regional level UPS impacts for FoPIA 1 where generally shared with the exception of “improved cooking stove” where Dodoma had significantly higher expectations. For FoPIA 2 “kitchen garden” had the most significant differences, and again Dodoma had significantly higher impact assessments than Morogoro.

Regarding the second research question, even though differences existed between household clusters, the statistical analysis was inconclusive regarding significant differences of impact scores between different clusters of households for all UPS. Some explanations were analyzed but further research is needed to determine whether household clusters influence differences in impact scores.

The results of this thesis may be useful to re-align research and UPS implementation and adaptation activities, streamline management, prioritize development investment, and for institutional learning in terms of improved collective and collaborative performance by reflecting on the evaluation experience on what has worked and what has not worked and pursuing change. Finally, this thesis serves as a milestone in helping improve food security among the rural stakeholders as a part of the Trans-SEC project.

9. Annexes

Annex 1.

Table 17 Overview of UPS implementation status and key challenges at FoPIA 2 (August/September 2015)

Chain link	UPS		Idifu	Ilolo
Natural resources/ Food production	Rainwater harvesting & Fertilizer micro-dosing	Implementation status	Implemented	Implemented
		Comments		
		Key challenges	Diverse group following different sub-UPS foci; difficult for farmers to differentiate between droughts and UPS effects	Diverse group following different sub-UPS foci; difficult for farmers to differentiate between droughts and UPS effects
Processing	millet/maize thresher	Implementation status	Implemented	Implemented
		Comments	Machine at place but still not implemented. Group is small with high member shifts as compared to initial group composition, somewhat frustrated group.	Not started, somewhat frustrated group.
		Key challenges	Group is frustrated cause machine is not working; lack of mechanical introduction. Facilities for machined needed	Difficult to maintain the group while there is no machine
Natural resources	Tree Planting	Implementation status		Implemented
		Comments		Motivated, five month experiences.
		Key challenges		Drought in last planting season, survival/growth rates of planted tree seedlings on farms are low, sites for tree nursery with perennial water availability (and no costs) only distant from settlement

Chain link	UPS		Idifu	Ilolo
Consumption	Improved stoves	Implementation status	Implemented	Implemented
		Comments	Outscaling, motivated, five month experiences.	Outscaling, motivated, five month experiences.
		Key challenges	In beginning long drying process of constructed stoves.	Prevalent sandy soil in settlement area was poor for construction of stoves
Market	Sunflower Oil press	Implementation status	Implemented	Implemented
		Comments	Delivered, but not installed. Facilities for machine needed. Somewhat frustrated group.	Not started. Feasibility study from SUA assessed sunflower seed production as too low to economically produce oil.
		Key challenges	Building house for machine not finished yet. Low production of seeds to operate machine; conduction of training at risk.	Low production of seeds to operate machine; conduction of training at risk.
Processing	Storage Bags	Implementation status	Implemented	Implemented
		Comments	Not started. Price too high to afford bags. somewhat frustrated group.	Not started, somewhat frustrated group
		Key challenges	Too expensive, participants still think it will cost between 5.000 and 10.000 TSh, frustrated group.	Too expensive, participants still think it will cost between 5.000 and 10.000 TSh

Chain link	UPS		Idifu	Ilolo
Food Production/Consumption	**Kitchen garden & Nutrition education**	**Implementation status**	Implemented	Implemented
		Comments	Initial experiences, motivated group.	Initial experiences, motivated group.
		Key challenges	Only 2 days of implementation, so – difficult for participants to report changes. Water availability is still a challenge	Only 1 day of implementation, so – difficult for participants to report changes. Water availability is still a challenge

Chain link	UPS		Ilakala	Changarawe
Natural resources/ Food production	Rainwater harvesting & Fertilizer micro-dosing	Implementation status	Implemented	Implemented
		Comments		
		Key challenges	Farmers thoughts of baby plots harvest will belong to researchers; therefore they selected sites of low fertility. Old members need assistance to implement tied ridges	Farmers thoughts of baby plots harvest will belong to researchers; therefore they selected sites of low fertility
Natural resources	Byproduct for Bioenergy (Biochar)	Implementation status	Implemented	
		Comments	Adjustment needed	
		Key challenges	Installed just one week before, therefore difficult to report. Too hot to cook food and therefore dangerous for users and children around. Too high to operate.	
Processing	millet/maize thresher	Implementation status	Implemented	Implemented
		Comments	Adjustments needed	Adjustments needed
		Key challenges	Low yields in past harvest. Farmers need to transport the heavy machine to the field which is not possible (lack of tools; oxen, tractor)	Low yields in past harvest. Farmers need to transport the heavy machine to the field which is not possible (lack of tools; oxen, tractor)

Chain link	UPS		Ilakala	Changarawe
Consumption	**Improved stoves**	**Implementation status**	Implemented	Implemented
		Comments	Outscaling, motivated, five month experiences.	Outscaling, motivated, five month experiences.
		Key challenges	Misunderstanding of needing burnt bricks as material for construction (costs as hindering factor)	Receiving wooden frame for building blocks on time; they do not know how to repair cracks.
Processing	**Storage Bags**	**Implementation status**	Implemented	Implemented
		Comments	Partly implemented (only one bag in use), somewhat frustrated group	Partly implemented,
		Key challenges	Too expensive, participants still think it will cost between 5.000 and 10.000 TSh	Some have bags, but maize was not shelled yet. For others, too expensive, participants still think it will cost between 5.000 and 10.000 TSh
Food Production	**Poultry-crop integration**	**Implementation status**		Implemented
		Comments		Only few weeks of implementation, so – difficult for participants to report changes
		Key challenges		Rivalry for allocation of funds

Chain link	UPS		Ilakala	Changarawe
Food Production/Consumption	**Kitchen garden & Nutrition education**	**Implementation status**	Implemented	Implemented
		Comments	Initial experiences, motivated group.	Initial experiences, motivated group.
		Key challenges	Only few weeks of implementation, so – difficult for participants to report changes apart from expectations	Only few weeks of implementation, so – difficult for participants to report changes apart from expectations

Annex 2 Idifu Box-plots

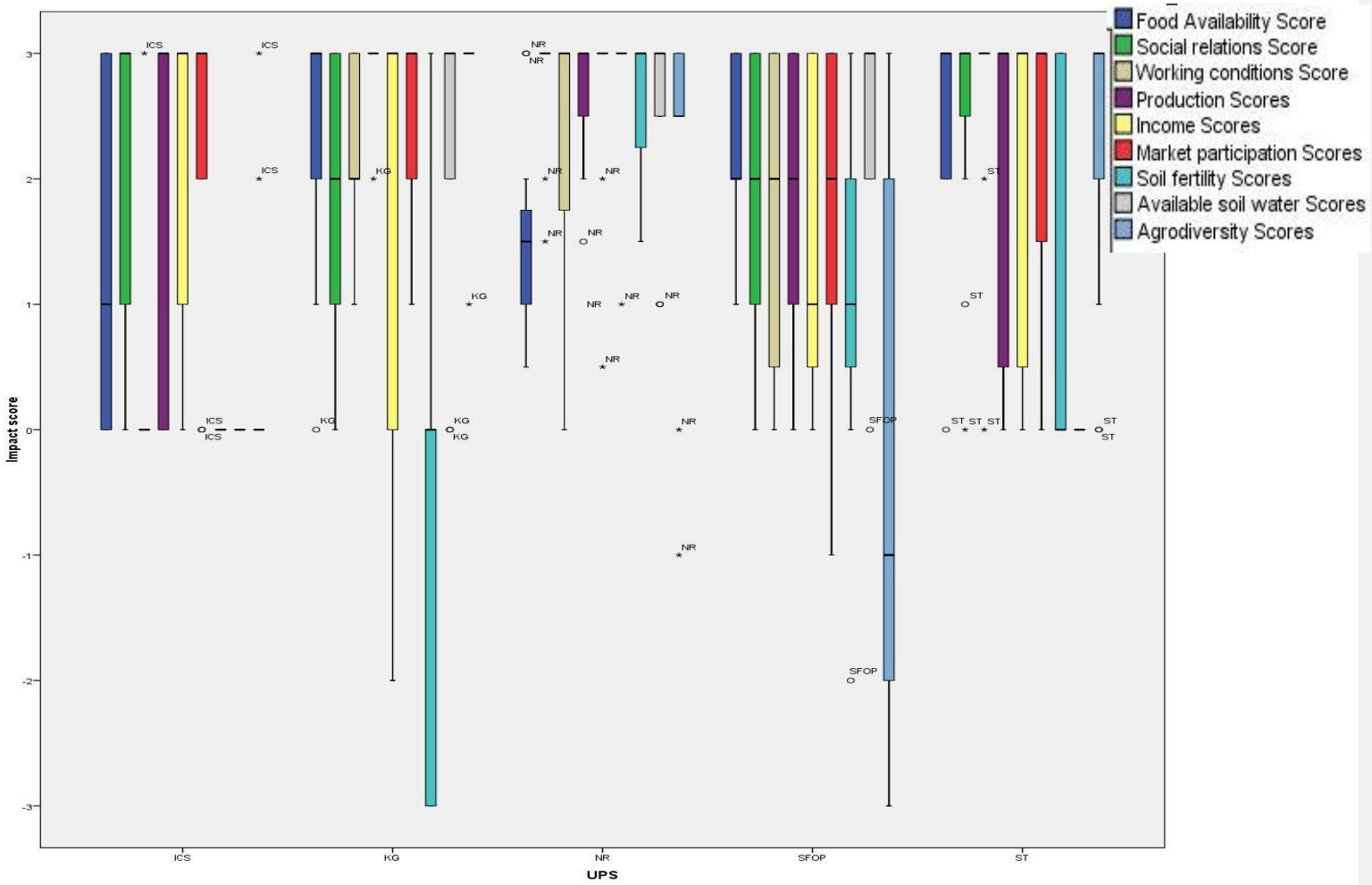


Figure 10 Box-plots UPS Idifu FoPIA 1. ICS=Improved cooking stove. KG=Kitchen garden. NR=RWH/MF. SFOP=Sunflower oil pressing. ST=Seed thresher.

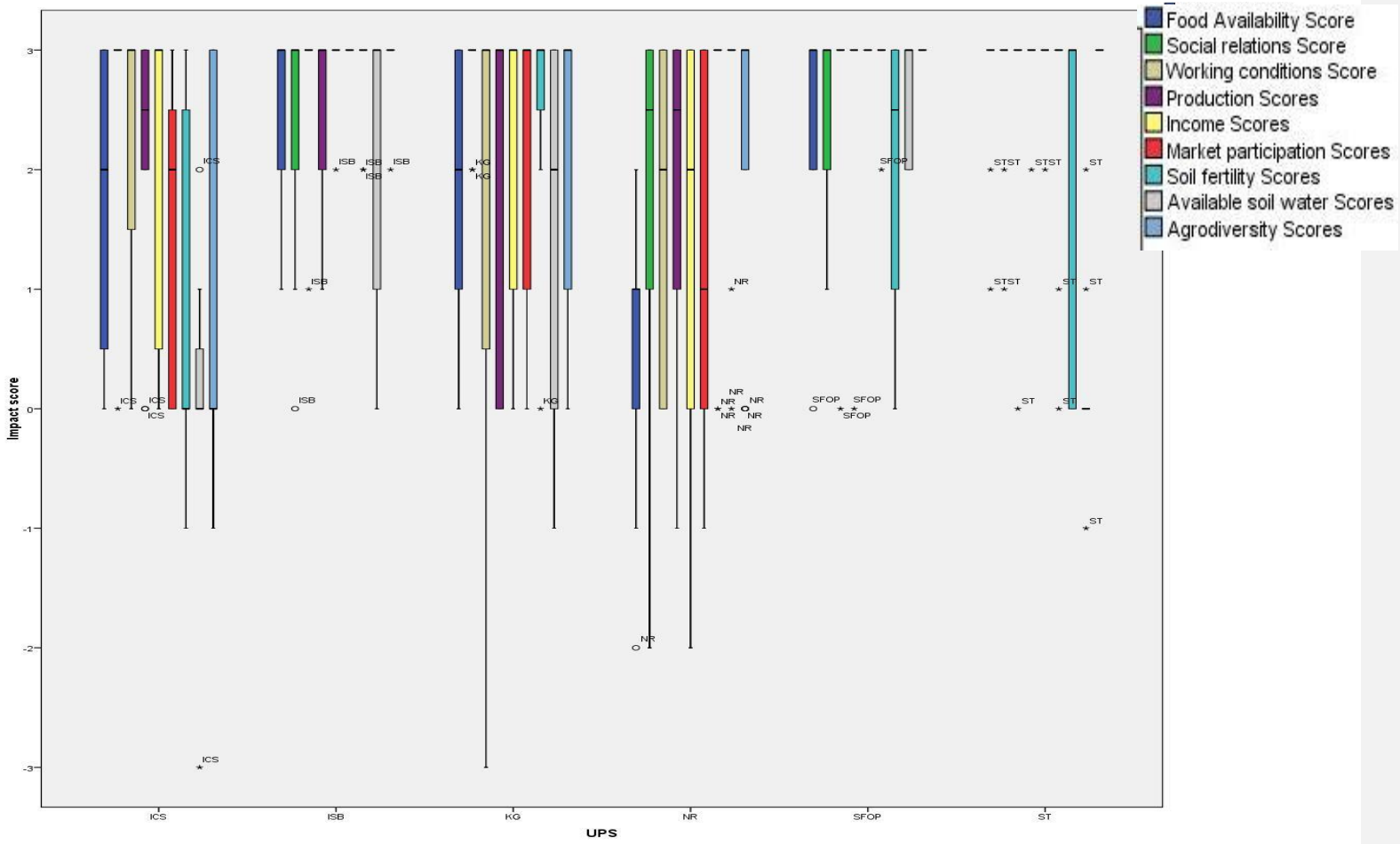


Figure 11 Boxplots UPS Idifu FoPIA 2. ICS=Improved cooking stove. ISB=Improved storage bags. KG=Kitchen garden. NR=RWH/MF. SFOP=Sunflower oil pressing. ST=Seedthresher.

Annex 4 Ilolo Boxplots

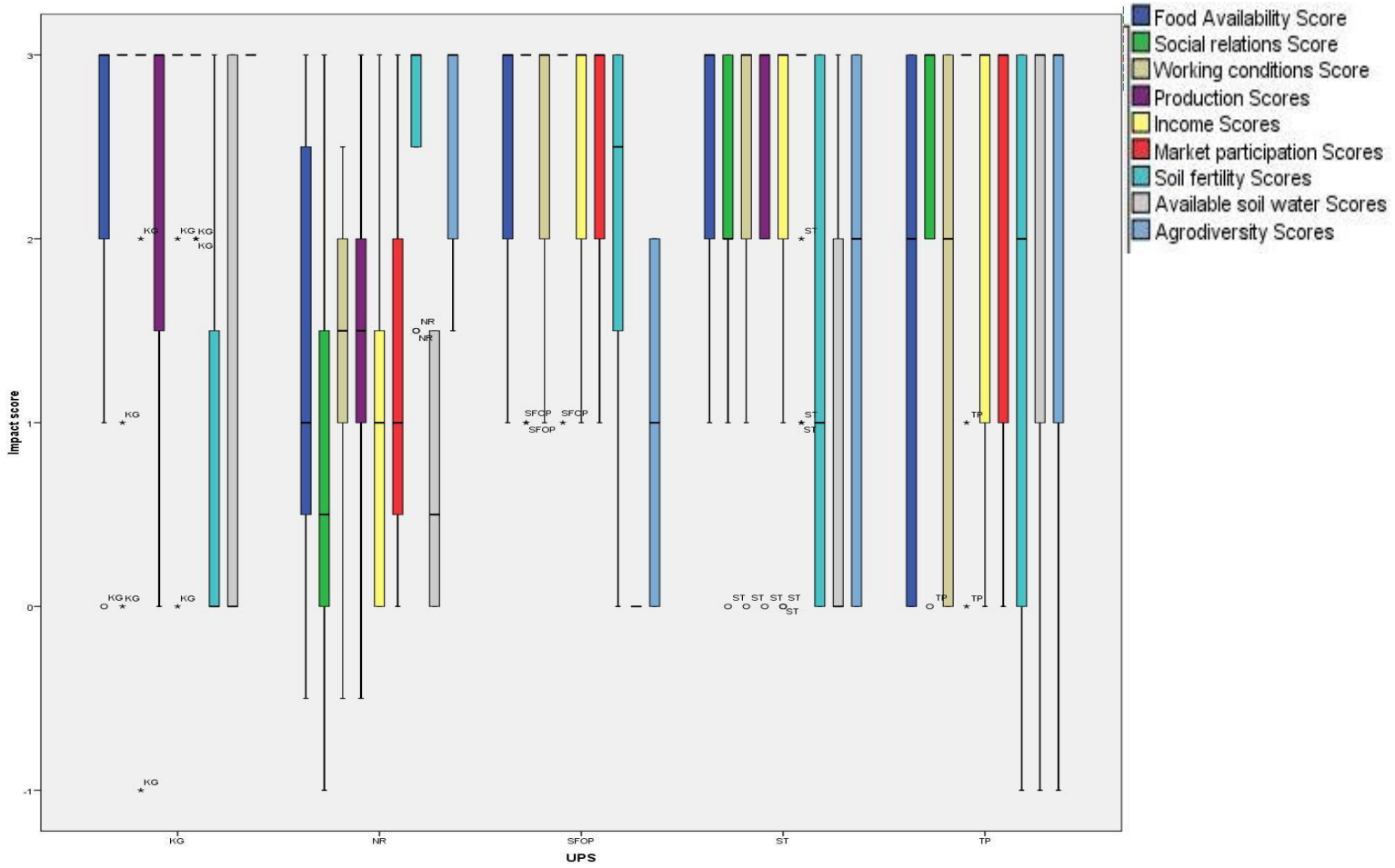


Figure 12 Boxplots UPS Ilolo FoPIA 1.

KG=Kitchen garden. NR=RWH/MF. SFOP=Sunflower oil pressing. ST=Seed thresher. TP=Tree planting.

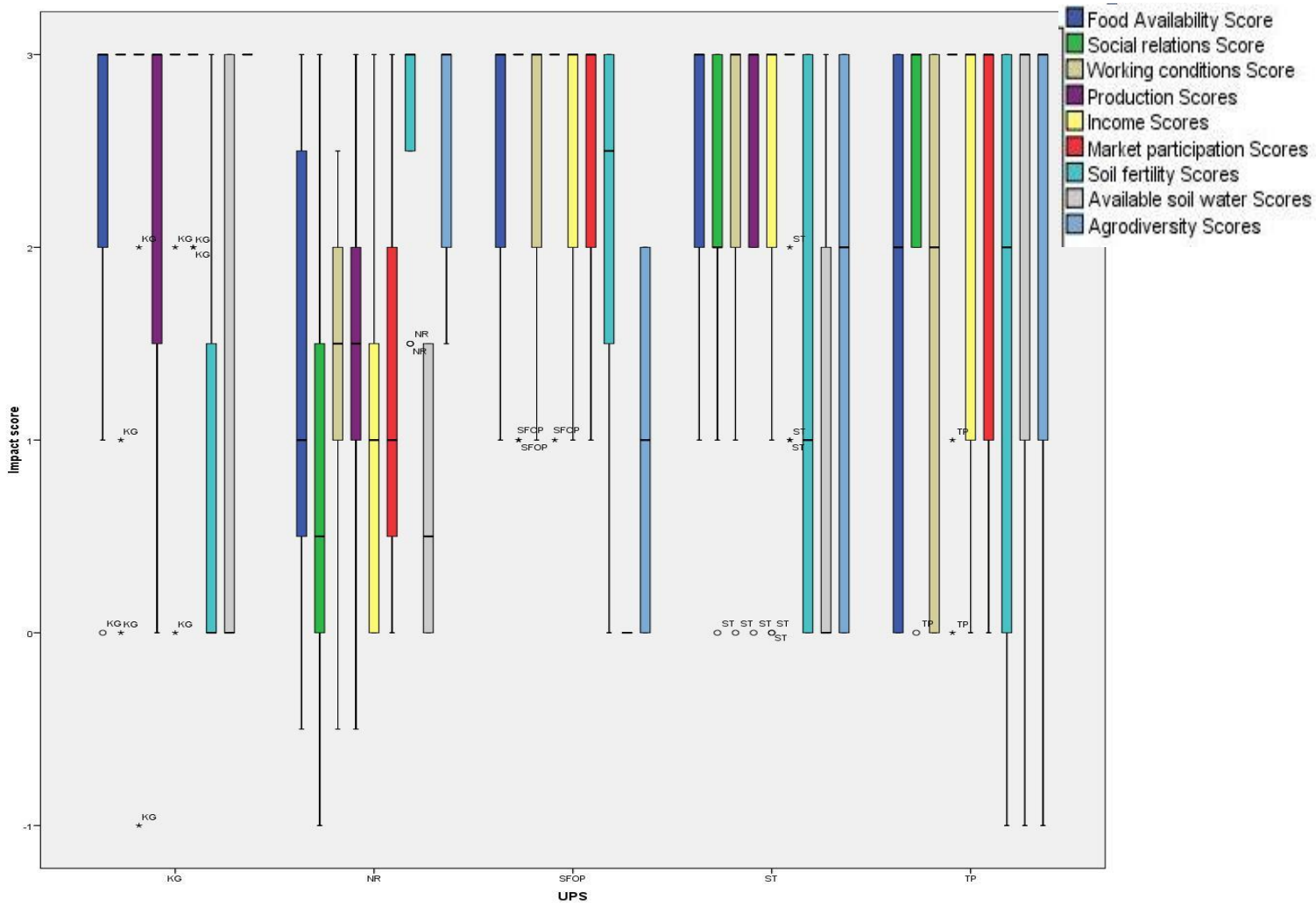


Figure 13 Boxplots UPS Ilolo FoPIA 2.

KG=Kitchen garden. NR=RWH/MF. SFOP=Sunflower oil pressing. ST=Seed thresher. TP=Tree planting.

Annex 5 Ilakala Boxplots

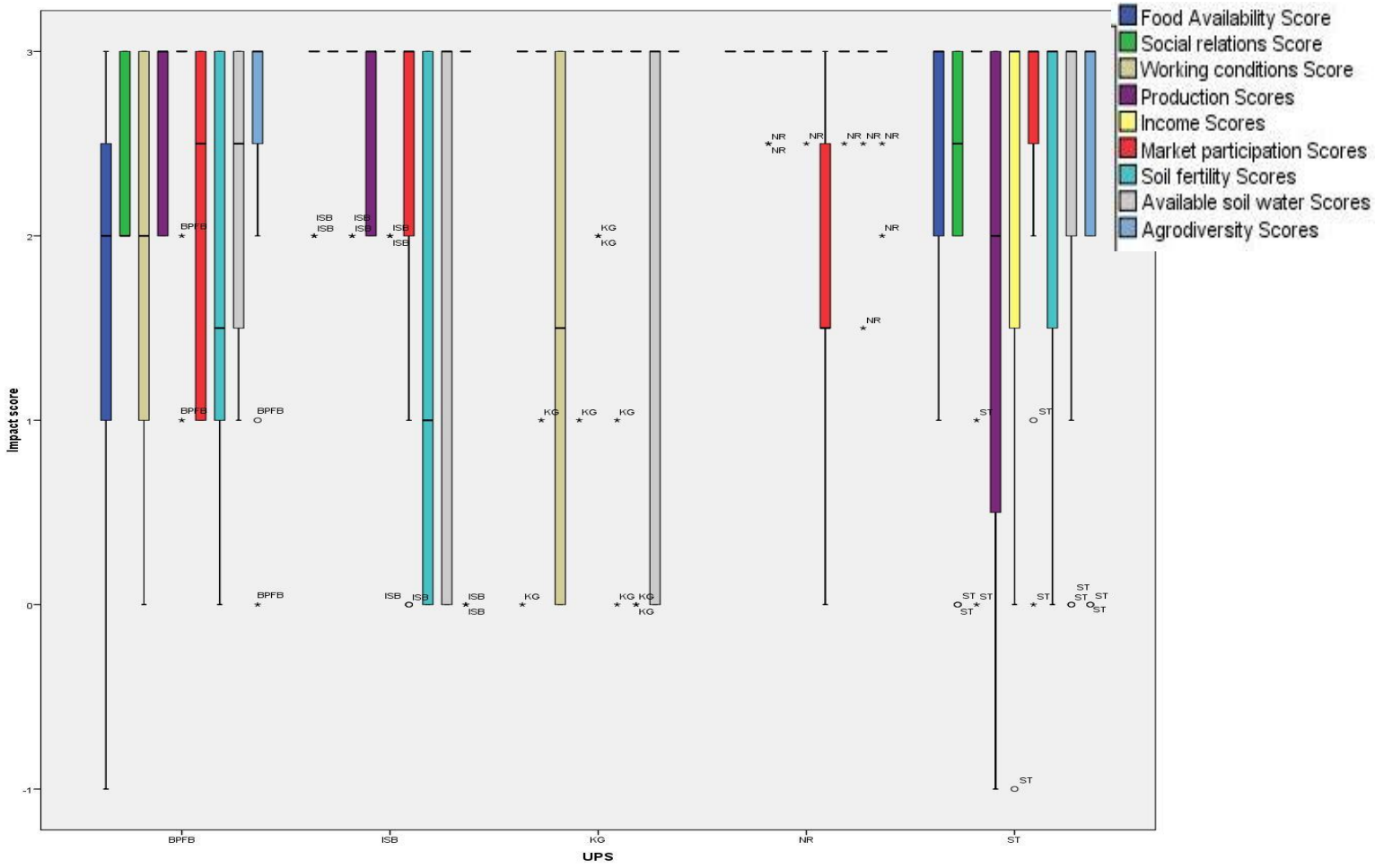


Figure 14: Boxplots UPS Ilakala FoPIA 1.

BPFB=Byproduct for bioenergy. ISB=Improved storage bags. KG=Kitchen garden. NR=RWH/MF. ST=Seed thresher.

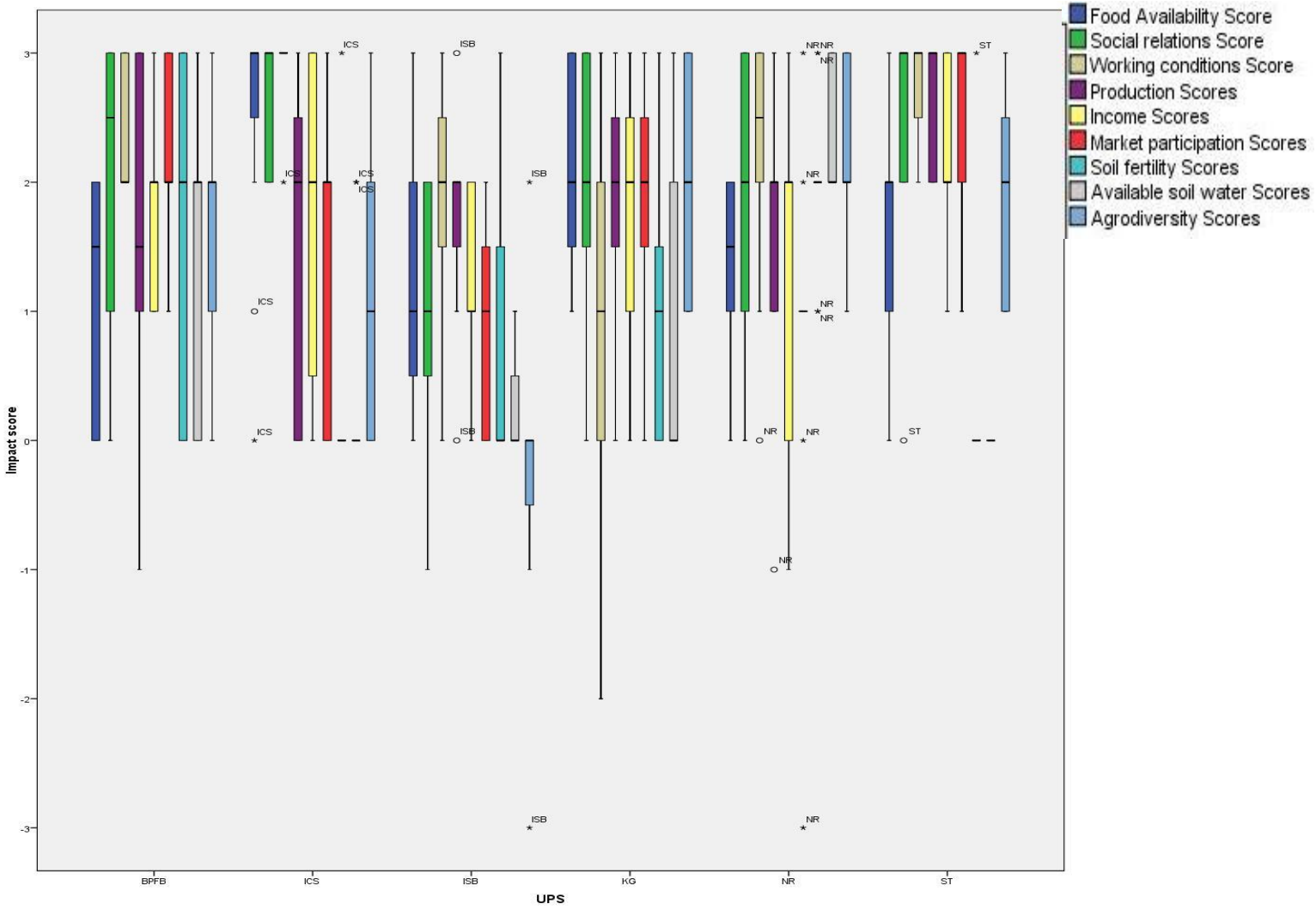


Figure 15: Boxplots UPS Ilakala FoPIA 2. BPFB=Byproduct for bioenergy. ICS=Improved cooking stoves. ISB=Improved storage bags. KG=Kitchen garden. NR=RWH/MF. ST=Seed thresher.

Annex 6 Changarawe Boxplots

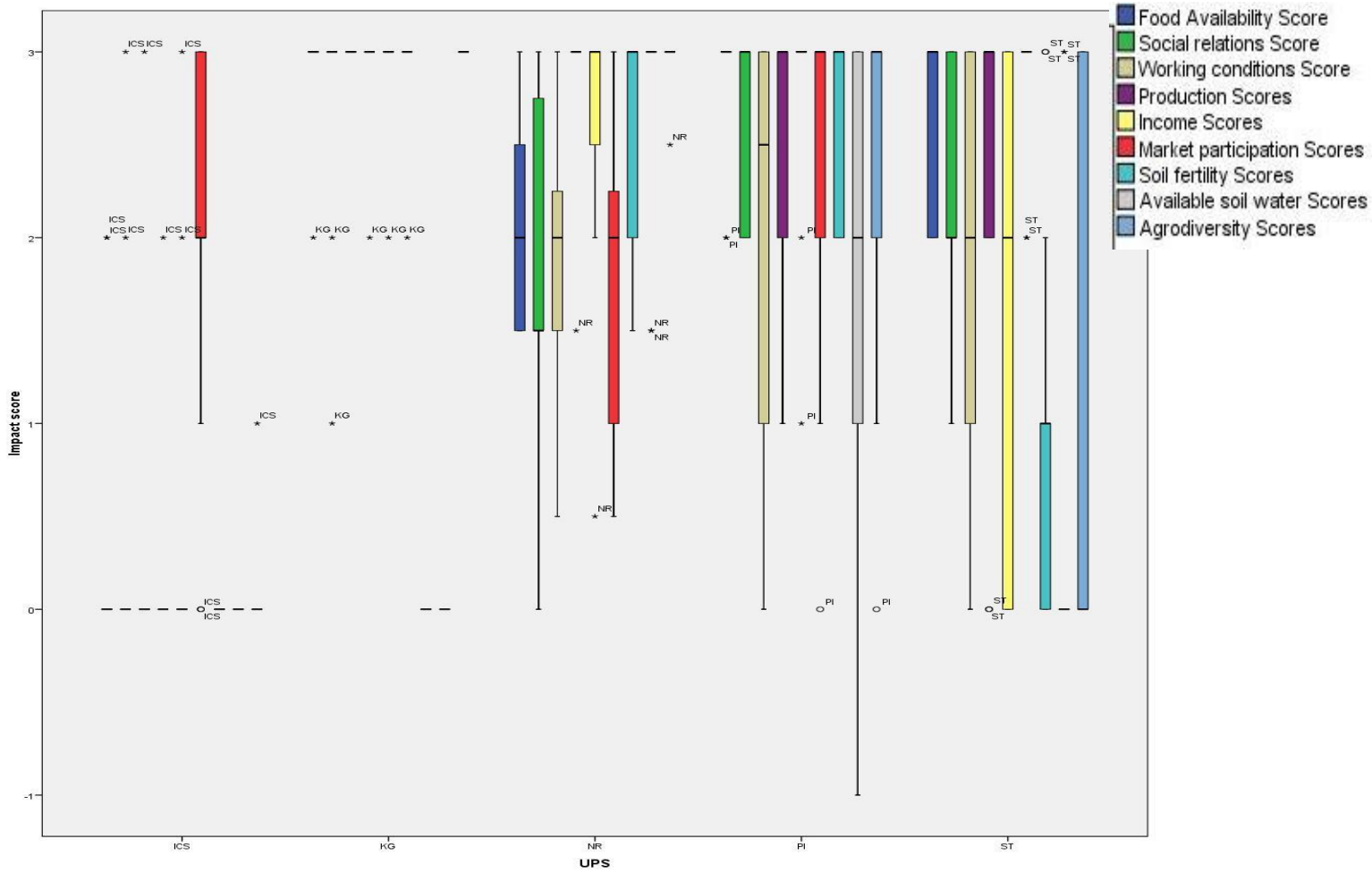


Figure 16 Boxplots UPS Changarawe FoPIA 1. ICS=Improved cooking stove. KG=Kitchen garden. NR=RWH/MF. PI=Poultry integration. ST=Seed thresher.

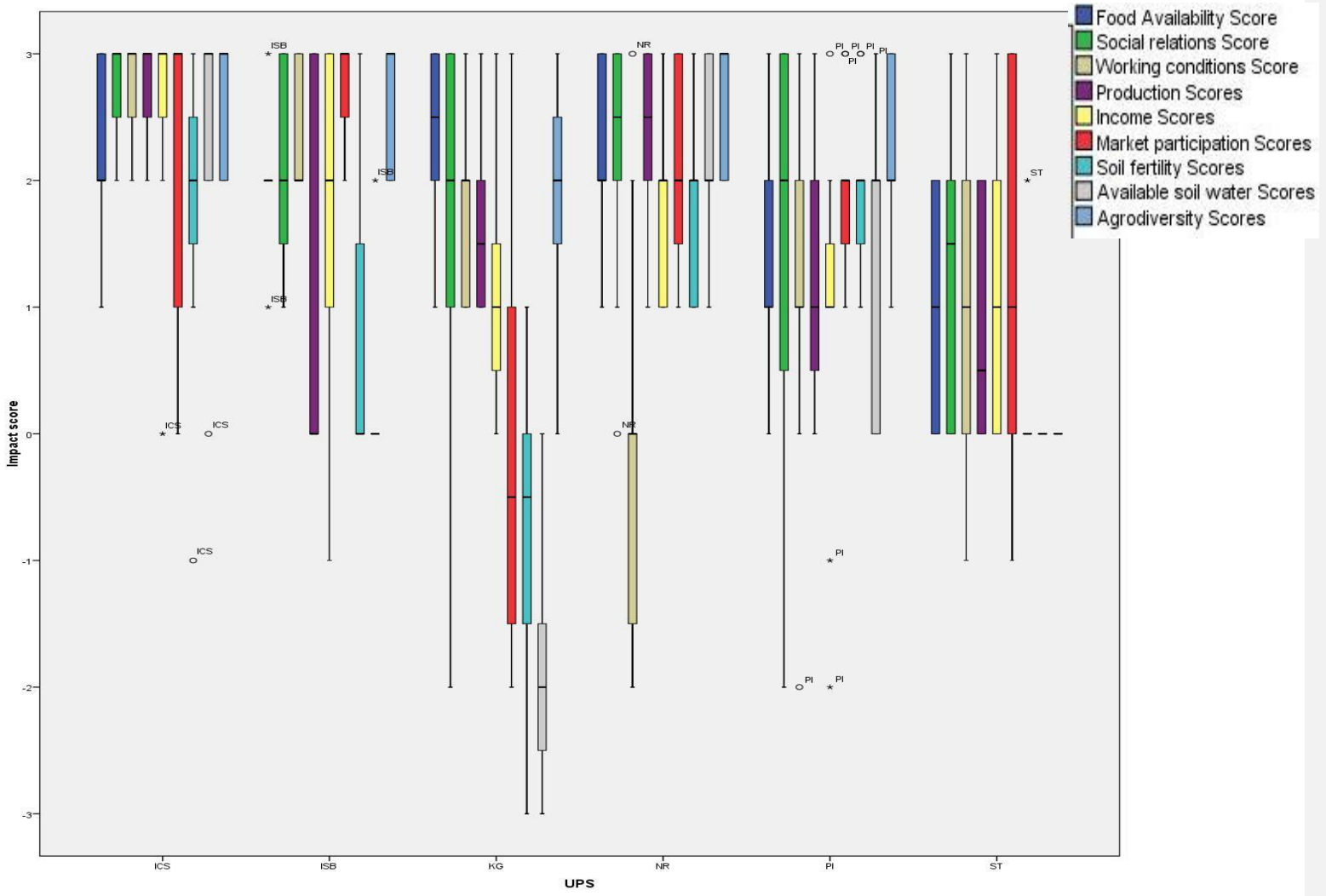
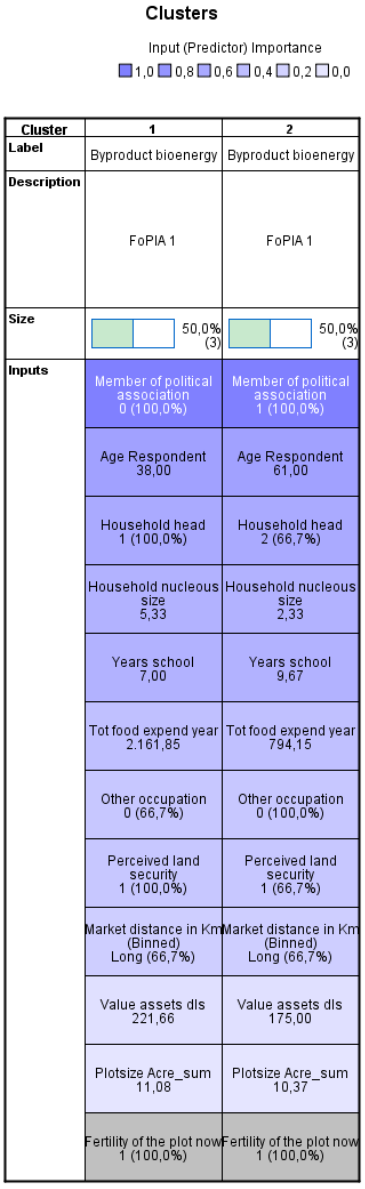
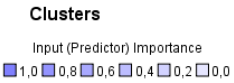


Figure 17 Boxplots UPS ChangaraweFoPIA 2. ICS=Improved cooking stoves. ISB=Improved storage bags. KG=Kitchen garden. NR=RWH/MF. PI=Poultry integration. ST=Seed thresher.

Annex 7 Household characteristics analysis results: Byproduct for bioenergy



Cluster	1	2
Label	Byproduct bioenergy	Byproduct bioenergy
Description	FoPIA 1	FoPIA 1
Size	50,0% (3)	50,0% (3)
Inputs	Member of political association 0 (100,0%)	Member of political association 1 (100,0%)
	Age Respondent 38,00	Age Respondent 61,00
	Household head 1 (100,0%)	Household head 2 (66,7%)
	Household nucleous size 5,33	Household nucleous size 2,33
	Years school 7,00	Years school 9,67
	Tot food expend year 2.161,85	Tot food expend year 794,15
	Other occupation 0 (66,7%)	Other occupation 0 (100,0%)
	Perceived land security 1 (100,0%)	Perceived land security 1 (66,7%)
	Market distance in Km (Binned) Long (66,7%)	Market distance in Km (Binned) Long (66,7%)
	Value assets dls 221,66	Value assets dls 175,00
	Plotsize Acre_sum 11,08	Plotsize Acre_sum 10,37
	Fertility of the plot now 1 (100,0%)	Fertility of the plot now 1 (100,0%)



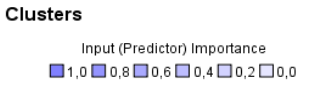
Cluster	1	2
Label	Byproduct bioenergy	Byproduct bioenergy
Description	FoPIA 2	FoPIA 2
Size	60,0% (3)	40,0% (2)
Inputs	Household head 1,00 (100,0%)	Household head 2,00 (100,0%)
	Tot food expend year 750,03	Tot food expend year 1.853,02
	Value assets dls 145,00	Value assets dls 68,73
	Fertility of the plot now 1,00 (100,0%)	Fertility of the plot now 1,00 (50,0%)
	Age Respondent 30,67	Age Respondent 47,50
	Plotsize Acre_sum 1,56	Plotsize Acre_sum 3,94
	Household nucleous size 3,67	Household nucleous size 6,50
	Market distance in Km (Binned) Short (66,7%)	Market distance in Km (Binned) Short (100,0%)
	Other occupation 0,00 (66,7%)	Other occupation 0,00 (100,0%)
	Member of political association 0,00 (66,7%)	Member of political association 1,00 (50,0%)
	Perceived land security 1,00 (66,7%)	Perceived land security 1,00 (50,0%)
	Years school 2,33	Years school 3,50

Table 18 Byproduct for bioenergy, cluster composition FoPIA 1 and FoPIA 2

Descriptives Byproduct for bioenergy FoPIA 1					Descriptives Byproduct for bioenergy FoPIA 2			
Food security criteria	Cluster number	N	Mean	Std. Deviation	Cluster number	N	Mean	Std. Deviation
Food Availability Score	1	3	2.00	1.00	1	3	1.67	0.58
	2	3	1.33	1.53	2	2	1.00	1.41
	Total	6	1.67	1.21	Total	5	1.40	0.89
Social relations Score	1	3	2.67	0.58	1	3	2.67	0.58
	2	3	2.33	0.58	2	2	2.00	1.41
	Total	6	2.50	0.55	Total	5	2.40	0.89
Working conditions Score	1	3	1.33	1.53	1	3	2.33	0.58
	2	3	2.33	1.15	2	2	2.50	0.71
	Total	6	1.83	1.33	Total	5	2.40	0.55
Production Scores	1	3	2.67	0.58	1	3	2.33	1.15
	2	3	2.33	0.58	2	2	1.50	0.71
	Total	6	2.50	0.55	Total	5	2.00	1.00
Income Scores	1	3	2.33	1.15	1	3	2.33	0.58
	2	3	3.00	0.00	2	2	1.50	0.71
	Total	6	2.67	0.82	Total	5	2.00	0.71
Market participation Scores	1	3	2.67	0.58	1	3	2.67	0.58
	2	3	1.67	1.15	2	2	1.50	0.71
	Total	6	2.17	0.98	Total	5	2.20	0.84
Soil fertility Scores	1	3	2.67	0.58	1	3	2.67	0.58
	2	3	2.00	1.73	2	2	1.00	1.41
	Total	6	2.33	1.21	Total	5	2.00	1.22
Available soil water Scores	1	3	3.00	0.00	1	3	2.33	0.58
	2	3	2.00	1.00	2	2	1.00	1.41
	Total	6	2.50	0.84	Total	5	1.80	1.10
Agrodiversity Scores	1	3	2.67	0.58	1	3	2.33	0.58
	2	3	2.33	1.15	2	2	1.00	1.41
	Total	6	2.50	0.84	Total	5	1.80	1.10

Table 19 for bioenergy cluster comparison FoPIA 1 and FoPIA 2

Annex 8 Household characteristics analysis results: Improved cooking stove



Cluster	1	2	3
Label	Imp. cooking stove	Imp. cooking stove	Imp. cooking stove
Description	FoPIA 1	FoPIA 1	FoPIA 2
Size	50,0% (6)	25,0% (3)	25,0% (3)
Inputs	Fertility of the plot now 1 (100,0%)	Fertility of the plot now 0 (100,0%)	Fertility of the plot now 1 (100,0%)
	Member of political association 0 (100,0%)	Member of political association 0 (66,7%)	Member of political association 1 (100,0%)
	Other occupation 0 (100,0%)	Other occupation 0 (66,7%)	Other occupation 1 (100,0%)
	Plotsize Acre_sum 3,58	Plotsize Acre_sum 4,17	Plotsize Acre_sum 13,00
	Tot food expend year 1.107,40	Tot food expend year 368,40	Tot food expend year 1.191,22
	Household head 1 (66,7%)	Household head 1 (100,0%)	Household head 1 (100,0%)
	Value assets dls 87,71	Value assets dls 156,96	Value assets dls 221,36
	Years school 5,83	Years school 5,33	Years school 3,33
	Age Respondent 53,33	Age Respondent 44,33	Age Respondent 52,00
	Perceived land security 1 (83,3%)	Perceived land security 1 (100,0%)	Perceived land security 1 (100,0%)
	Market distance in Km (Binned) Medium (50,0%)	Market distance in Km (Binned) Medium (66,7%)	Market distance in Km (Binned) Medium (66,7%)
	Household nucleous size 4,50	Household nucleous size 4,33	Household nucleous size 4,67

Table 20 “Improved cooking stove” cluster composition FoPIA 1.

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	1	2	3
Label	Imp. cooking stove	Imp. cooking stove	Imp. cooking stove
Description	FoPIA 2	FoPIA 2	FoPIA 2
Size	22,7% (5)	59,1% (13)	18,2% (4)
Inputs	Household head 1,00 (100,0%)	Household head 2,00 (84,6%)	Household head 1,00 (100,0%)
	Other occupation 0,00 (100,0%)	Other occupation 0,00 (69,2%)	Other occupation 1,00 (100,0%)
	Member of political association 1,00 (100,0%)	Member of political association 0,00 (61,5%)	Member of political association 0,00 (100,0%)
	Value assets dls 458,75	Value assets dls 101,90	Value assets dls 52,98
	Household nucleous size 6,00	Household nucleous size 3,46	Household nucleous size 5,75
	Perceived land security 1,00 (60,0%)	Perceived land security 1,00 (100,0%)	Perceived land security 1,00 (100,0%)
	Plotsize Acre_sum 2,26	Plotsize Acre_sum 2,06	Plotsize Acre_sum 9,88
	Tot food expend year 1.486,38	Tot food expend year 834,87	Tot food expend year 1.773,60
	Fertility of the plot now 1,00 (80,0%)	Fertility of the plot now 1,00 (53,8%)	Fertility of the plot now 1,00 (100,0%)
	Age Respondent 49,20	Age Respondent 54,46	Age Respondent 38,50
	Years school 5,60	Years school 4,38	Years school 7,00
	Market distance in Km (Binned) Short (100,0%)	Market distance in Km (Binned) Short (76,9%)	Market distance in Km (Binned) Short (100,0%)

Table 21 “Improved cooking stove” cluster composition FoPIA 2.

Descriptives Imp. Cooking stoves FoPIA 1					Descriptives Imp. Cooking stoves FoPIA 2			
Food security criteria	Cluster number	N	Mean	Std. Deviation	Cluster number	N	Mean	Std. Deviation
Food Availability Score	1	6	1.33	1.51	1	4	1.50	0.58
	2	3	0.33	0.58	2	12	1.33	1.50
	3	3	1.00	1.73	3	4	1.25	1.26
	Total	12	1.00	1.35	Total	20	1.35	1.27
Social relations Score	1	6	1.67	1.51	1	4	2.25	1.50
	2	3	2.00	1.73	2	12	2.25	1.14
	3	3	2.00	1.73	3	4	2.00	1.41
	Total	12	1.83	1.47	Total	20	2.20	1.20
Working conditions Score	1	6	0.50	1.22	1	4	3.00	0.00
	2	3	1.00	1.73	2	12	2.08	1.24
	3	3	0.00	0.00	3	4	1.50	1.73
	Total	12	0.50	1.17	Total	20	2.15	1.27
Production Scores	1	6	1.00	1.55	1	4	1.50	1.00
	2	3	2.00	1.73	2	12	1.33	1.50
	3	3	2.00	1.73	3	4	2.00	1.41
	Total	12	1.50	1.57	Total	20	1.50	1.36
Income Scores	1	6	2.00	1.55	1	4	1.50	1.29
	2	3	1.33	1.53	2	12	1.17	1.53
	3	3	2.00	1.73	3	4	1.25	1.50
	Total	12	1.83	1.47	Total	20	1.25	1.41
Market participation Scores	1	6	1.83	1.47	1	4	1.00	1.83
	2	3	1.67	1.53	2	12	1.33	1.37
	3	3	3.00	0.00	3	4	1.00	1.41
	Total	12	2.08	1.31	Total	20	1.20	1.40
Soil fertility Scores	1	6	0.00	0.00	1	4	1.50	1.73
	2	3	0.00	0.00	2	12	0.92	1.31
	3	3	0.00	0.00	3	4	1.00	1.41
	Total	12	0.00	0.00	Total	20	1.05	1.36
Available soil water Scores	1	6	0.00	0.00	1	4	1.75	1.26
	2	3	0.00	0.00	2	12	0.75	1.14
	3	3	0.00	0.00	3	4	0.25	2.50
	Total	12	0.00	0.00	Total	20	0.85	1.50
Agrodiversity Scores	1	6	0.33	0.82	1	4	2.25	1.50
	2	3	1.00	1.73	2	12	1.75	1.36
	3	3	0.00	0.00	3	4	1.50	1.73
	Total	12	0.42	1.00	Total	20	1.80	1.40

Table 22 "Improved cooking stove" cluster comparison FoPIA 1 and FoPIA 2.

Annex 9 Household characteristics analysis results: “Improved storage bags”

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	1	2
Label	Imp. storage bags	Imp. storage bags
Description	FoPIA 1	FoPIA 1
Size	50,0% (3)	50,0% (3)
Inputs	Household head 1 (100,0%)	Household head 2 (100,0%)
	Member of political association 0 (100,0%)	Member of political association 1 (66,7%)
	Market distance in Km (Binned) Short (66,7%)	Market distance in Km (Binned) Long (66,7%)
	Fertility of the plot now 1 (66,7%)	Fertility of the plot now 1 (100,0%)
	Other occupation 0 (100,0%)	Other occupation 0 (66,7%)
	Perceived land security 1 (100,0%)	Perceived land security 1 (66,7%)
	Age Respondent 63,33	Age Respondent 54,00
	Household nucleous size 4,00	Household nucleous size 3,00
	Tot food expend year 727,97	Tot food expend year 1.202,25
	Plotsize Acre_sum 9,25	Plotsize Acre_sum 6,20
	Value assets dls 99,61	Value assets dls 104,99
	Years school 5,33	Years school 5,33

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	2	1	3
Label	Imp. storage bags	Imp. storage bags	Imp. storage bags
Description	FoPIA 2	FoPIA 2	FoPIA 2
Size	52,4% (11)	23,8% (5)	23,8% (5)
Inputs	Other occupation 0,00 (100,0%)	Other occupation 0,00 (100,0%)	Other occupation 1,00 (100,0%)
	Member of political association 0,00 (100,0%)	Member of political association 1,00 (100,0%)	Member of political association 0,00 (80,0%)
	Perceived land security 1,00 (81,8%)	Perceived land security 1,00 (100,0%)	Perceived land security 0,00 (60,0%)
	Fertility of the plot now 1,00 (100,0%)	Fertility of the plot now 1,00 (60,0%)	Fertility of the plot now 1,00 (80,0%)
	Household head 1,00 (63,6%)	Household head 1,00 (100,0%)	Household head 1,00 (100,0%)
	Tot food expend year 816,11	Tot food expend year 1.440,06	Tot food expend year 1.307,04
	Household nucleous size 4,00	Household nucleous size 4,80	Household nucleous size 3,20
	Plotsize Acre_sum 3,29	Plotsize Acre_sum 1,98	Plotsize Acre_sum 1,53
	Value assets dls 705,32	Value assets dls 298,06	Value assets dls 120,87
	Years school 5,18	Years school 3,60	Years school 4,80
	Market distance in Km (Binned) Short (72,7%)	Market distance in Km (Binned) Short (80,0%)	Market distance in Km (Binned) Short (80,0%)
	Age Respondent 49,64	Age Respondent 46,00	Age Respondent 49,00

Table 23 "Improved storage bags" cluster composition FoPIA 1 and FoPIA 2.

Descriptives Imp. Storage bags FoPIA 1

Food security criteria	Cluster number	N	Mean	Std. Deviation
Food Availability Score	1	3	3.00	0.00
	2	3	3.00	0.00
	Total	6	3.00	0.00
Social relations Score	1	3	3.00	0.00
	2	3	3.00	0.00
	Total	6	3.00	0.00
Working conditions Score	1	3	3.00	0.00
	2	3	2.67	0.58
	Total	6	2.83	0.41
Production Scores	1	3	3.00	0.00
	2	3	3.00	0.00
	Total	6	3.00	0.00
Income Scores	1	3	3.00	0.00
	2	3	3.00	0.00
	Total	6	3.00	0.00
Market participation Scores	1	3	3.00	0.00
	2	3	3.00	0.00
	Total	6	3.00	0.00
Soil fertility Scores	1	3	1.33	1.53
	2	3	2.33	1.15
	Total	6	1.83	1.33
Available soil water Scores	1	3	2.00	1.73
	2	3	2.33	1.15
	Total	6	2.17	1.33
Agrodiversity Scores	1	3	3.00	0.00
	2	3	3.00	0.00
	Total	6	3.00	0.00

Descriptives Imp. Storage bags FoPIA 2

Food security criteria	Cluster number	N	Mean	Std. Deviation
Food Availability Score	1	5	2.40	0.89
	2	11	1.36	1.12
	3	5	1.60	0.55
	Total	21	1.67	1.02
Social relations Score	1	5	2.40*	0.89
	2	11	1.64	1.12
	3	5	0.20*	1.10
	Total	21	1.48	1.29
Working conditions Score	1	5	2.00	1.73
	2	11	2.00	1.18
	3	5	1.80	1.30
	Total	21	1.95	1.28
Production Scores	1	5	1.60	1.52
	2	11	1.55	1.37
	3	5	1.00	1.58
	Total	21	1.43	1.40
Income Scores	1	5	2.40	1.34
	2	11	1.09	1.58
	3	5	1.40	1.52
	Total	21	1.48	1.54
Market participation Scores	1	5	2.40	1.34
	2	11	1.36	1.63
	3	5	1.20	1.92
	Total	21	1.57	1.63
Soil fertility Scores	1	5	1.80	1.64
	2	11	1.36	1.36
	3	5	0.80	1.30
	Total	21	1.33	1.39
Available soil water Scores	1	5	1.00	1.41
	2	11	0.82	1.60
	3	5	0.80	1.30
	Total	21	0.86	1.42
Agrodiversity Scores	1	5	2.40	1.34
	2	11	1.45	1.44
	3	5	-0.20	2.17
	Total	21	1.29	1.79

Table 24 Improved storage bags cluster comparison FoPIA 1 and FoPIA 2. * criteria with a significant difference (α≤0.05/3).

Annex 10 Household characteristics analysis results: “Kitchen garden”

Clusters

Input (Predictor) Importance
1,0 0,8 0,6 0,4 0,2 0,0

Cluster	1	2	3
Label	Kitchen garden	Kitchen garden	Kitchen garden
Description	FoPIA 1	FoPIA 1	FoPIA 1
Size	46,2% (12)	26,9% (7)	26,9% (7)
Inputs	Fertility of the plot now 1 (100,0%)	Fertility of the plot now 1 (100,0%)	Fertility of the plot now 0 (100,0%)
	Other occupation 0 (91,7%)	Other occupation 1 (100,0%)	Other occupation 0 (71,4%)
	Market distance in Km (Binned) Short (50,0%)	Market distance in Km (Binned) Short (100,0%)	Market distance in Km (Binned) Short (71,4%)
	Age Respondent 54,58	Age Respondent 37,71	Age Respondent 43,86
	Years school 4,75	Years school 8,00	Years school 6,57
	Tot food expend year 1.308,14	Tot food expend year 534,16	Tot food expend year 1.492,81
	Perceived land security 1 (83,3%)	Perceived land security 1 (71,4%)	Perceived land security 0 (57,1%)
	Member of political association 1 (50,0%)	Member of political association 1 (85,7%)	Member of political association 0 (57,1%)
	Household nucleous size 5,50	Household nucleous size 4,57	Household nucleous size 5,00
	Value assets dls 315,59	Value assets dls 216,31	Value assets dls 368,04
	Plotsize Acre_sum 10,13	Plotsize Acre_sum 6,86	Plotsize Acre_sum 8,32
	Household head 1 (83,3%)	Household head 1 (85,7%)	Household head 1 (85,7%)

Table 25 “Kitchen garden” cluster composition FoPIA 1.

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	1	2	3
Label	Kitchen garden	Kitchen garden	Kitchen garden
Description	FoPIA 2	FoPIA 2	FoPIA 2
Size	43,3% (13)	30,0% (9)	26,7% (8)
Inputs	Other occupation 0,00 (100,0%)	Other occupation 1,00 (100,0%)	Other occupation 0,00 (62,5%)
	Household head 1,00 (92,3%)	Household head 1,00 (100,0%)	Household head 2,00 (87,5%)
	Years school 7,00	Years school 7,00	Years school 5,25
	Member of political association 0,00 (53,8%)	Member of political association 0,00 (77,8%)	Member of political association 0,00 (100,0%)
	Plotsize Acre_sum 2,56	Plotsize Acre_sum 2,79	Plotsize Acre_sum 1,20
	Tot food expend year 1.359,73	Tot food expend year 966,95	Tot food expend year 499,65
	Fertility of the plot now 1,00 (69,2%)	Fertility of the plot now 1,00 (100,0%)	Fertility of the plot now 1,00 (87,5%)
	Value assets dls 261,88	Value assets dls 101,74	Value assets dls 97,05
	Age Respondent 43,54	Age Respondent 37,78	Age Respondent 45,00
	Perceived land security 1,00 (61,5%)	Perceived land security 1,00 (88,9%)	Perceived land security 1,00 (62,5%)
	Household nucleous size 5,85	Household nucleous size 5,22	Household nucleous size 4,75
	Market distance in Km (Binned) Short (76,9%)	Market distance in Km (Binned) Short (88,9%)	Market distance in Km (Binned) Short (100,0%)

Table 26 “Kitchen garden” cluster composition FoPIA 2.

Descriptives Kitchen garden FoPIA 1					Descriptives Kitchen garden FoPIA 2			
Food security criteria	Cluster number	N	Mean	Std. Deviation	Cluster number	N	Mean	Std. Deviation
Food Availability Score	1	12	2.67	0.89	1	11	1.45	1.44
	2	7	2.29	1.11	2	6	2.00	0.89
	3	6	2.50	0.84	3	6	2.17	1.17
	Total	25	2.52	0.92	Total	23	1.78	1.24
Social relations Score	1	12	2.92	0.29	1	11	2.00	0.89
	2	7	2.57	1.13	2	6	2.33	1.21
	3	6	2.00	1.26	3	6	2.00	1.26
	Total	25	2.60	0.91	Total	23	2.09	1.04
Working conditions Score	1	12	2.33	1.15	1	11	2.00	0.77
	2	7	2.00	1.29	2	6	0.83	1.94
	3	6	2.83	0.41	3	6	1.17	1.47
	Total	25	2.36	1.08	Total	23	1.48	1.38
Production Scores	1	12	2.83	0.39	1	11	1.55	1.04
	2	7	2.57	1.13	2	6	1.83	1.17
	3	6	3.00	0.00	3	6	2.33	0.52
	Total	25	2.80	0.65	Total	23	1.83	0.98
Income Scores	1	12	2.58	0.90	1	11	1.27	1.10
	2	7	2.29	1.50	2	6	1.83	0.98
	3	6	3.00	0.00	3	6	1.33	1.63
	Total	25	2.60	1.00	Total	23	1.43	1.20
Market participation Scores	1	12	3.00	0.00	1	11	1.18	1.47
	2	7	2.71	0.49	2	6	0.67	1.75
	3	6	2.83	0.41	3	6	1.50	1.22
	Total	25	2.88	0.33	Total	23	1.13	1.46
Soil fertility Scores	1	12	1.00	1.95	1	11	0.55	1.75
	2	7	0.86	2.27	2	6	0.50	1.76
	3	6	1.00	1.55	3	6	1.00	0.89
	Total	25	0.96	1.88	Total	23	0.65	1.53
Available soil water Scores	1	12	1.67	1.50	1	11	-0.18	1.72
	2	7	2.00	1.41	2	6	0.67	1.51
	3	6	2.00	1.55	3	6	1.67	1.03
	Total	25	1.84	1.43	Total	23	0.52	1.65
Agrodiversity Scores	1	12	3.00	0.00	1	11	1.91	1.04
	2	7	3.00	0.00	2	6	1.50	1.22
	3	6	3.00	0.00	3	6	1.50	1.38
	Total	25	3.00	0.00	Total	23	1.70	1.15

Table 27 “Kitchen garden” cluster comparison FoPIA 1 and FoPIA 2.

Annex 11 Household characteristics analysis results: RWH/MF

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	2	1
Label	Natural resources	Natural resources
Description	FoPIA 1	FoPIA 1
Size	53,1% (17)	46,9% (15)
Inputs	Household head 1 (100,0%)	Household head 2 (80,0%)
	Market distance in Km (Binned) Short (82,4%)	Market distance in Km (Binned) Medium (60,0%)
	Plotsize Acre_sum 10,19	Plotsize Acre_sum 2,94
	Value assets dls 268,22	Value assets dls 66,86
	Years school 5,65	Years school 3,07
	Tot food expend year 925,34	Tot food expend year 526,35
	Age Respondent 43,76	Age Respondent 50,07
	Member of political association 0 (70,6%)	Member of political association 0 (86,7%)
	Perceived land security 1 (76,5%)	Perceived land security 1 (66,7%)
	Household nucleous size 3,82	Household nucleous size 3,67
	Fertility of the plot now 1 (88,2%)	Fertility of the plot now 1 (86,7%)
	Other occupation 0 (58,8%)	Other occupation 0 (60,0%)

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	2	1
Label	Natural resources	Natural resources
Description	FoPIA 2	FoPIA 2
Size	62,9% (22)	37,1% (13)
Inputs	Household head 1,00 (100,0%)	Household head 2,00 (100,0%)
	Household nucleous size 6,05	Household nucleous size 3,38
	Value assets dls 330,48	Value assets dls 45,38
	Tot food expend year 1.214,69	Tot food expend year 590,01
	Plotsize Acre_sum 2,73	Plotsize Acre_sum 1,48
	Years school 6,23	Years school 4,46
	Fertility of the plot now 1,00 (86,4%)	Fertility of the plot now 1,00 (69,2%)
	Market distance in Km (Binned) Short (68,2%)	Market distance in Km (Binned) Short (84,6%)
	Other occupation 0,00 (63,6%)	Other occupation 0,00 (53,8%)
	Perceived land security 1,00 (81,8%)	Perceived land security 1,00 (76,9%)
	Member of political association 0,00 (59,1%)	Member of political association 0,00 (53,8%)
	Age Respondent 50,23	Age Respondent 49,85

Table 28 “Rain water harvesting and micro fertilizing” cluster composition FoPIA 1 and FoPIA 2.

Descriptives Natural resources FoPIA 1					Descriptives Natural resources FoPIA 2			
Food security criteria	Cluster number	N	Mean	Std. Deviation	Cluster number	N	Mean	Std. Deviation
Food Availability Score	1	15	1.67	0.94	1	12	2.08	1.08
	2	17	1.82	1.16	2	19	1.84	0.96
	Total	32	1.75	1.05	Total	31	1.94	1.00
Social relations Score	1	15	1.73	1.21	1	12	2.00	1.21
	2	17	1.68	1.48	2	19	2.58	0.61
	Total	32	1.70	1.34	Total	31	2.35	0.91
Working conditions Score	1	15	2.30	0.96	1	12	1.75	1.66
	2	17	1.82	0.81	2	19	2.00	1.45
	Total	32	2.05	0.90	Total	31	1.90	1.51
Production Scores	1	15	2.50	0.89	1	12	1.83	1.27
	2	17	2.12	1.11	2	19	2.26	0.99
	Total	32	2.30	1.01	Total	31	2.10	1.11
Income Scores	1	15	2.30	1.05	1	12	1.42	1.44
	2	17	1.85	1.23	2	19	2.05	1.03
	Total	32	2.06	1.16	Total	31	1.81	1.22
Market participation Scores	1	15	2.17	0.90	1	12	1.17	1.64
	2	17	1.62	0.93	2	19	1.95	0.97
	Total	32	1.88	0.94	Total	31	1.65	1.31
Soil fertility Scores	1	15	2.63	0.61	1	12	1.83	0.94
	2	17	2.59	0.59	2	19	2.32	0.95
	Total	32	2.61	0.59	Total	31	2.13	0.96
Available soil water Scores	1	15	2.40	0.95	1	12	1.92	1.08
	2	17	1.68	1.25	2	19	2.16	1.21
	Total	32	2.02	1.16	Total	31	2.06	1.15
Agrodiversity Scores	1	15	2.57	0.78	1	12	2.42	0.67
	2	17	2.38	1.02	2	19	2.53	0.84
	Total	32	2.47	0.91	Total	31	2.48	0.77

Table 29 "Rain water harvesting and micro fertilizing" cluster comparison FoPIA 1 and FoPIA 2.

Annex 12 Household characteristics analysis results: “Poultry integration”

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	2	1
Label	Poultry integration	Poultry integration
Description	FoPIA 1	FoPIA 2
Size	60,0% (3)	40,0% (2)
Inputs	Other occupation 0 (100,0%)	Other occupation 1 (100,0%)
	Market distance in Km (Binned) Short (66,7%)	Market distance in Km (Binned) Long (100,0%)
	Member of political association 1 (66,7%)	Member of political association 0 (100,0%)
	Household head 2 (100,0%)	Household head 2 (50,0%)
	Value assets dls 55,36	Value assets dls 878,14
	Perceived land security 0 (66,7%)	Perceived land security 0 (100,0%)
	Age Respondent 44,00	Age Respondent 51,50
	Household nucleous size 3,00	Household nucleous size 4,00
	Tot food expend year 1.361,08	Tot food expend year 1.654,48
	Years school 2,33	Years school 3,50
	Plotsize Acre_sum 2,50	Plotsize Acre_sum 2,65
	Fertility of the plot now 1 (100,0%)	Fertility of the plot now 1 (100,0%)

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	1	2
Label	Poultry integration	Poultry integration
Description	FoPIA 2	FoPIA 2
Size	50,0% (2)	50,0% (2)
Inputs	Value assets dls 110,72	Value assets dls 520,20
	Perceived land security 0,00 (100,0%)	Perceived land security 1,00 (100,0%)
	Market distance in Km (Binned) Long (100,0%)	Market distance in Km (Binned) Medium (50,0%)
	Household head 2,00 (50,0%)	Household head 1,00 (100,0%)
	Other occupation 0,00 (100,0%)	Other occupation 0,00 (50,0%)
	Years school 3,50	Years school 9,00
	Age Respondent 52,50	Age Respondent 43,50
	Plotsize Acre_sum 0,80	Plotsize Acre_sum 1,92
	Household nucleous size 3,50	Household nucleous size 4,00
	Tot food expend year 1.621,38	Tot food expend year 1.704,11
	Member of political association 1,00 (50,0%)	Member of political association 1,00 (50,0%)
	Fertility of the plot now 1,00 (100,0%)	Fertility of the plot now 1,00 (100,0%)

Table 30 "Poultry integration" cluster composition FoPIA 1 and FoPIA 2.

Descriptives Poultry integration FoPIA 1					Descriptives Poultry integration FoPIA 2			
Food security criteria	Cluster number	N	Mean	Std. Deviation	Cluster number	N	Mean	Std. Deviation
Food Availability Score	1	2	3.00	0.00	1	2	1.50	0.71
	2	3	2.67	0.58	2	2	2.00	0.00
	Total	5	2.80	0.45	Total	4	1.75	0.50
Social relations Score	1	2	3.00	0.00	1	2	2.00	0.00
	2	3	2.67	0.58	2	2	3.00	0.00
	Total	5	2.80	0.45	Total	4	2.50	0.58
Working conditions Score	1	2	0.50	0.71	1	2	0.00	1.41
	2	3	2.00	1.00	2	2	2.00	0.00
	Total	5	1.40	1.14	Total	4	1.00	1.41
Production Scores	1	2	2.50	0.71	1	2	1.50	0.71
	2	3	2.33	1.15	2	2	1.50	0.71
	Total	5	2.40	0.89	Total	4	1.50	0.58
Income Scores	1	2	2.50	0.71	1	2	-0.50	2.12
	2	3	3.00	0.00	2	2	1.50	0.71
	Total	5	2.80	0.45	Total	4	0.50	1.73
Market participation Scores	1	2	2.00	1.41	1	2	1.00	0.00
	2	3	2.00	1.73	2	2	2.00	0.00
	Total	5	2.00	1.41	Total	4	1.50	0.58
Soil fertility Scores	1	2	2.50	0.71	1	2	1.50	0.71
	2	3	2.67	0.58	2	2	1.50	0.71
	Total	5	2.60	0.55	Total	4	1.50	0.58
Available soil water Scores	1	2	0.50	0.71	1	2	1.50	0.71
	2	3	1.67	2.31	2	2	1.00	1.41
	Total	5	1.20	1.79	Total	4	1.25	0.96
Agrodiversity Scores	1	2	3.00	0.00	1	2	2.50	0.71
	2	3	2.33	1.15	2	2	2.00	0.00
	Total	5	2.60	0.89	Total	4	2.25	0.50

Table 31 "Poultry integration" cluster comparison FoPIA 1 and FoPIA 2.

Annex 13 Household characteristics analysis results: “Seed thresher”

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	3	1	2
Label	Seed thresher	Seed thresher	Seed thresher
Description	FoPIA 1	FoPIA 1	FoPIA 1
Size	37,9% (11)	34,5% (10)	27,6% (8)
Inputs	Other occupation 1 (100,0%)	Other occupation 0 (90,0%)	Other occupation 0 (75,0%)
	Household head 1 (81,8%)	Household head 1 (100,0%)	Household head 2 (87,5%)
	Household nucleous size 6,09	Household nucleous size 4,70	Household nucleous size 3,50
	Age Respondent 43,73	Age Respondent 46,50	Age Respondent 56,88
	Fertility of the plot now 1 (100,0%)	Fertility of the plot now 1 (60,0%)	Fertility of the plot now 1 (75,0%)
	Market distance in Km (Binned) Short (54,5%)	Market distance in Km (Binned) Medium (50,0%)	Market distance in Km (Binned) Short (75,0%)
	Member of political association 0 (63,6%)	Member of political association 0 (90,0%)	Member of political association 0 (50,0%)
	Tot food expend year 1.367,50	Tot food expend year 1.062,18	Tot food expend year 694,05
	Perceived land security 1 (100,0%)	Perceived land security 1 (80,0%)	Perceived land security 1 (75,0%)
	Value assets dls 142,85	Value assets dls 213,49	Value assets dls 91,30
	Years school 4,64	Years school 6,50	Years school 5,38
	Plotsize Acre_sum 9,28	Plotsize Acre_sum 6,32	Plotsize Acre_sum 6,24

Table 32 “Seed thresher” cluster composition FoPIA 1.

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	2	3	1
Label	Seed Thresher	Seed Thresher	Seed Thresher
Description	FoPIA 2	FoPIA 2	FoPIA 2
Size	52,4% (11)	38,1% (8)	9,5% (2)
Inputs	Member of political association 1,00 (90,9%)	Member of political association 0,00 (87,5%)	Member of political association 0,00 (100,0%)
	Value assets dls 255,83	Value assets dls 148,74	Value assets dls 986,32
	Market distance in Km (Binned) Short (81,8%)	Market distance in Km (Binned) Short (87,5%)	Market distance in Km (Binned) Long (100,0%)
	Other occupation 0,00 (72,7%)	Other occupation 0,00 (100,0%)	Other occupation 1,00 (100,0%)
	Perceived land security 1,00 (100,0%)	Perceived land security 0,00 (50,0%)	Perceived land security 0,00 (50,0%)
	Plotsize Acre_sum 2,61	Plotsize Acre_sum 1,53	Plotsize Acre_sum 1,57
	Years school 6,55	Years school 4,00	Years school 7,00
	Age Respondent 51,73	Age Respondent 47,38	Age Respondent 36,00
	Household nucleous size 4,82	Household nucleous size 3,88	Household nucleous size 3,50
	Fertility of the plot now 1,00 (72,7%)	Fertility of the plot now 1,00 (100,0%)	Fertility of the plot now 1,00 (100,0%)
	Tot food expend year 1.236,35	Tot food expend year 869,43	Tot food expend year 1.323,58
	Household head 1,00 (90,9%)	Household head 1,00 (100,0%)	Household head 1,00 (100,0%)

Table 33 "Seed thresher" cluster composition FoPIA 2.

Descriptives Seed thresher FoPIA 1					Descriptives Seed thresher FoPIA 2			
Food security criteria	Cluster number	N	Mean	Std. Deviation	Cluster number	N	Mean	Std. Deviation
Food Availability Score	1	10	2.50	0.97	1	2	1.50	0.71
	2	8	2.50	0.76	2	10	1.20	1.32
	3	11	2.64	0.67	3	7	1.86	1.21
	Total	29	2.55	0.78	Total	19	1.47	1.22
Social relations Score	1	10	2.60	0.52	1	2	1.50	2.12
	2	8	2.50	0.53	2	10	1.90	1.66
	3	11	2.27	1.27	3	7	2.00	1.15
	Total	29	2.45	0.87	Total	19	1.89	1.45
Working conditions Score	1	10	2.40	0.97	1	2	2.00	1.41
	2	8	3.00	0.00	2	10	2.00	1.25
	3	11	2.55	1.04	3	7	1.57	1.51
	Total	29	2.62	0.86	Total	19	1.84	1.30
Production Scores	1	10	2.50	1.08	1	2	0.50	0.71
	2	8	2.50	0.76	2	10	1.90	1.37
	3	11	2.27	1.19	3	7	1.71	1.38
	Total	29	2.41	1.02	Total	19	1.68	1.34
Income Scores	1	10	2.10	1.20	1	2	0.50	0.71
	2	8	1.50	1.69	2	10	1.30	1.64
	3	11	2.45	1.21	3	7	1.57	1.51
	Total	29	2.07	1.36	Total	19	1.32	1.49
Market participation Scores	1	10	2.50	0.97	1	2	1.00	2.83
	2	8	2.38	0.92	2	10	1.50	1.43
	3	11	2.55	0.82	3	7	1.86	1.21
	Total	29	2.48	0.87	Total	19	1.58	1.43
Soil fertility Scores	1	10	0.90	1.20	1	2	0.00	0.00
	2	8	2.00	1.41	2	10	0.60	1.26
	3	11	1.45	1.51	3	7	0.43	1.62
	Total	29	1.41	1.40	Total	19	0.47	1.31
Available soil water Scores	1	10	0.50	1.08	1	2	0.00	0.00
	2	8	1.50	1.60	2	10	0.60	1.07
	3	11	0.91	1.38	3	7	0.14	1.77
	Total	29	0.93	1.36	Total	19	0.37	1.30
Agrodiversity Scores	1	10	2.00	1.33	1	2	0.00	0.00
	2	8	2.63	0.52	2	10	1.70	1.25
	3	11	2.09	1.38	3	7	1.29	1.60
	Total	29	2.21	1.18	Total	19	1.37	1.38

Table 34 “Seed thresher” cluster comparison FoPIA 1 and FoPIA 2.

Annex 14 Household characteristics analysis results: “Sunflower oil pressing”

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	3	2	1
Label	Sunflower oil press	Sunflower oil press	Sunflower oil press
Description	FoPIA 1	FoPIA 1	FoPIA 1
Size	52,9% (9)	35,3% (6)	11,8% (2)
Inputs	Fertility of the plot now 1 (100,0%)	Fertility of the plot now 1 (100,0%)	Fertility of the plot now 0 (100,0%)
	Household head 1 (100,0%)	Household head 2 (83,3%)	Household head 2 (100,0%)
	Plotsize Acre_sum 6,59	Plotsize Acre_sum 2,58	Plotsize Acre_sum 6,00
	Market distance in Km (Binned) Short (66,7%)	Market distance in Km (Binned) Short (100,0%)	Market distance in Km (Binned) Medium (100,0%)
	Member of political association 0 (88,9%)	Member of political association 1 (66,7%)	Member of political association 0 (50,0%)
	Other occupation 1 (55,6%)	Other occupation 1 (100,0%)	Other occupation 1 (100,0%)
	Tot food expend year 948,57	Tot food expend year 1.387,56	Tot food expend year 860,33
	Perceived land security 1 (100,0%)	Perceived land security 1 (83,3%)	Perceived land security 1 (100,0%)
	Years school 4,67	Years school 7,00	Years school 2,00
	Household nucleous size 5,67	Household nucleous size 4,83	Household nucleous size 3,50
	Age Respondent 44,00	Age Respondent 37,00	Age Respondent 45,00
	Value assets dls 401,26	Value assets dls 527,10	Value assets dls 119,63

Clusters

Input (Predictor) Importance

1,0 0,8 0,6 0,4 0,2 0,0

Cluster	2	1
Label	Sunflower oil press	Sunflower oil press
Description	FoPIA 2	FoPIA 2
Size	66,7% (2)	33,3% (1)
Inputs	Other occupation 0,00 (100,0%)	Other occupation 1,00 (100,0%)
	Perceived land security 1,00 (100,0%)	Perceived land security 0,00 (100,0%)
	Age Respondent 53,50	Age Respondent 60,00
	Plotsize Acre_sum 1,66	Plotsize Acre_sum 4,04
	Household head 1,00 (50,0%)	Household head 1,00 (100,0%)
	Market distance in Km (Binned) Short (50,0%)	Market distance in Km (Binned) Short (100,0%)
	Value assets dls 278,08	Value assets dls 49,63
	Tot food expend year 1.522,12	Tot food expend year 344,13
	Years school 3,50	Years school 7,00
	Household nucleous size 5,00	Household nucleous size 6,00
	Fertility of the plot now 1,00 (100,0%)	Fertility of the plot now 1,00 (100,0%)
	Member of political association 1,00 (100,0%)	Member of political association 1,00 (100,0%)

Table 35 "Sunflower oil press" cluster composition FoPIA 1 and FoPIA 2.

Descriptives Sunflower oil press FoPIA 1

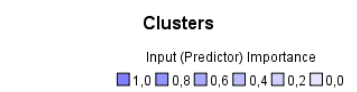
Food security criteria	Cluster number	N	Mean	Std. Deviation
Food Availability Score	1	2	2.50	0.71
	2	5	2.60	0.89
	3	9	2.44	0.73
	Total	16	2.50	0.73
Social relations Score	1	2	1.50	0.71
	2	5	2.60	0.89
	3	9	2.44	0.88
	Total	16	2.38	0.89
Working conditions Score	1	2	1.00	1.41
	2	5	2.60	0.89
	3	9	2.33	1.12
	Total	16	2.25	1.13
Production Scores	1	2	1.50	2.12
	2	5	2.60	0.89
	3	9	2.67	0.71
	Total	16	2.50	0.97
Income Scores	1	2	1.50	2.12
	2	5	2.40	0.89
	3	9	2.22	0.97
	Total	16	2.19	1.05
Market participation Scores	1	2	1.50	0.71
	2	5	2.40	0.55
	3	9	2.11	1.36
	Total	16	2.13	1.09
Soil fertility Scores	1	2	0.00	0.00
	2	5	1.80	1.30
	3	9	1.89	1.62
	Total	16	1.63	1.50
Available soil water Scores	1	2	2.50	0.71
	2	5	0.00	0.00
	3	9	1.56	1.51
	Total	16	1.19	1.42
Agrodiversity Scores	1	2	0.00	2.83
	2	5	1.20	0.84
	3	9	0.00	1.87
	Total	16	0.38	1.71

Descriptives Sunflower oil press FoPIA 2

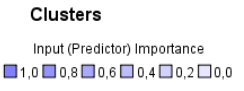
Food security criteria	Cluster number	N	Mean	Std. Deviation
Food Availability Score	1	1	0.00	
	2	2	0.00	0.00
	Total	3	0.00	0.00
Social relations Score	1	1	2.00	
	2	2	1.00	1.41
	Total	3	1.33	1.15
Working conditions Score	1	1	0.00	
	2	2	1.50	2.12
	Total	3	1.00	1.73
Production Scores	1	1	2.00	
	2	2	1.50	2.12
	Total	3	1.67	1.53
Income Scores	1	1	2.00	
	2	2	1.50	2.12
	Total	3	1.67	1.53
Market participation Scores	1	1	2.00	
	2	2	1.50	2.12
	Total	3	1.67	1.53
Soil fertility Scores	1	1	0.00	
	2	2	0.00	0.00
	Total	3	0.00	0.00
Available soil water Scores	1	1	0.00	
	2	2	0.00	0.00
	Total	3	0.00	0.00
Agrodiversity Scores	1	1	1.00	
	2	2	1.50	2.12
	Total	3	1.33	1.53

Table 36 "Sunflower oil press" cluster comparison FoPIA 1 and FoPIA 2.

Annex 14 Household characteristics analysis results: “Tree Planting”



Cluster	1	2
Label	Tree planting	Tree planting
Description	FoPIA 1	FoPIA 1
Size	80,0% (8)	20,0% (2)
Inputs	Other occupation 1 (100,0%)	Other occupation 0 (100,0%)
	Fertility of the plot now 1 (87,5%)	Fertility of the plot now 0 (100,0%)
	Perceived land security 1 (100,0%)	Perceived land security 1 (50,0%)
	Plotsize Acre_sum 5,52	Plotsize Acre_sum 16,00
	Value assets dls 100,74	Value assets dls 272,67
	Age Respondent 43,88	Age Respondent 55,00
	Tot food expend year 962,08	Tot food expend year 1.581,68
	Member of political association 0 (75,0%)	Member of political association 0 (100,0%)
	Years school 4,62	Years school 3,50
	Household head 1 (62,5%)	Household head 2 (50,0%)
	Household nucleous size 5,62	Household nucleous size 6,00
	Market distance in Km (Binned) Short (100,0%)	Market distance in Km (Binned) Short (100,0%)



Cluster	1	2
Label	Tree planting	Tree planting
Description	FoPIA 2	FoPIA 2
Size	60,0% (3)	40,0% (2)
Inputs	Tot food expend year 441,19	Tot food expend year 1.952,28
	Member of political association 0,00 (100,0%)	Member of political association 1,00 (100,0%)
	Value assets dls 315,62	Value assets dls 893,42
	Other occupation 0,00 (100,0%)	Other occupation 0,00 (50,0%)
	Plotsize Acre_sum 1,32	Plotsize Acre_sum 11,79
	Fertility of the plot now 1,00 (66,7%)	Fertility of the plot now 1,00 (100,0%)
	Perceived land security 1,00 (66,7%)	Perceived land security 1,00 (100,0%)
	Years school 4,33	Years school 7,00
	Household nucleous size 3,33	Household nucleous size 5,00
	Age Respondent 55,33	Age Respondent 60,50
	Household head 1,00 (100,0%)	Household head 1,00 (100,0%)
	Market distance in Km (Binned) Short (100,0%)	Market distance in Km (Binned) Short (100,0%)

Table 37 “Tree planting” cluster composition FoPIA 1 and FoPIA 2.

Descriptives Tree planting FoPIA 1					Descriptives Tree planting FoPIA 2			
Food security criteria	Cluster number	N	Mean	Std. Deviation	Cluster number	N	Mean	Std. Deviation
Food Availability Score	1	8	1.50	1.41	1	3	1.33	2.08
	2	2	1.50	2.12	2	2	2.50	0.71
	Total	10	1.50	1.43	Total	5	1.80	1.64
Social relations Score	1	8	2.38	1.06	1	3	2.00	1.73
	2	2	2.50	0.71	2	2	-0.50	0.71
	Total	10	2.40	0.97	Total	5	1.00	1.87
Working conditions Score	1	8	1.75	1.49	1	3	1.67	2.31
	2	2	0.50	0.71	2	2	0.50	0.71
	Total	10	1.50	1.43	Total	5	1.20	1.79
Production Scores	1	8	2.63	1.06	1	3	0.67	1.15
	2	2	2.00	1.41	2	2	-0.50	0.71
	Total	10	2.50	1.08	Total	5	0.20	1.10
Income Scores	1	8	2.00	1.41	1	3	1.33	2.89
	2	2	1.50	2.12	2	2	3.00	0.00
	Total	10	1.90	1.45	Total	5	2.00	2.24
Market participation Scores	1	8	2.13	1.36	1	3	1.00	1.73
	2	2	2.00	1.41	2	2	1.50	2.12
	Total	10	2.10	1.29	Total	5	1.20	1.64
Soil fertility Scores	1	8	1.63	1.69	1	3	2.00	1.73
	2	2	2.00	1.41	2	2	2.00	1.41
	Total	10	1.70	1.57	Total	5	2.00	1.41
Available soil water Scores	1	8	2.00	1.41	1	3	2.67	0.58
	2	2	1.00	2.83	2	2	2.00	1.41
	Total	10	1.80	1.62	Total	5	2.40	0.89
Agrodiversity Scores	1	8	2.13	1.36	1	3	3.00	0.00
	2	2	1.00	2.83	2	2	2.50	0.71
	Total	10	1.90	1.60	Total	5	2.80	0.45

Table 38 "Tree planting" cluster comparison FoPIA 1 and FoPIA 2.

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