UNIVERSITÀ CATTOLICA DEL SACRO CUORE
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Dottorato per il Sistema Agro-alimentare

Ph.D. in Agro-Food System

cycle XXXI

S.S.D: AGR/01; AGR/02; AGR/19

Food Security in Developing Countries: the case study of "Production of appropriate food: sufficient, safe and sustainable" project

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Academic Year 2017/2018

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"Dio mio, concedimi la forza di astenermi da ogni peccato e soprattutto da ogni giudizio affrettato e sconsiderato e da affermazioni su cose a me sconosciute o non perfettamente note.

Beato Niccolò Stenone

"I promise to work for a better world, where science and technology are used in socially responsible ways. I will not use my education for any purpose intended to harm human beings or the environment. Throughout my career, I will consider the ethical implications of my work before I take actions. While the demands placed upon me may be great, I sign this declaration because I recognise that individual responsibility is the first step on the path to peace."

Joseph Rotblat, Peace Nobel Prize, 1995

To Chiara,
To my family,
To who has been there,
and
To who will be there.

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List of Acronyms

ARC: Type of Rice genetic lines

ATE: Average Treatment Effect on the entire Sample

ATT: Average Treatment effect on the Treated

B: Beneficiary Families

BDO: Block Development Office

C3S: Production of Appropriate Food: Sufficient, Safe and Sustainable project

CFSVAs: Comprehensive Food Security and Vulnerability Analyses

CM: Child Mortality

CSI: Coping Strategy Index

CSOs: Civil Society Organizations

CST: Child Stunting

CWA: Child Wasting

DRC: Democratic Republic of Congo

ELCSA: Latin America and Caribbean Household Food Security Scale

FAFES: Faculty of Agriculture, Food and Environmental Science

FANTA: Food And Nutrition Technical Assistance

FAO: Food and Agriculture Organization of the United Nations

FCS: Food Consumption Score

FEWS NET: Famine Early Worming System Network

FIES: Food Insecurity Experience Scale

FS: Food Security

GAM: Group d'Assistance Mutuelle

GDP: Gross Domestic Products

GFSI: Global Food Security Index

GHI: Global Hunger Index

HAZ: height-for-age z-score

HCEs: Household Consumption and Expenditure survey

HDDs: Household Dietary Diversity Score

HEA: Household Economic Approach

HFIAS: Household Food Insecurity Access Scale

HH: Head of Household

HSSSM: United States Household Food Security Survey Module

IFAD: International Fund for Agricultural Development

IFPRI: International Food Policy Research Institute

IGA: Income Generating Activities

IGA: Income-Generating Activities

IMF: International Monetary Fund

INERA: Institute Nationale pour l'Etude et la Recherche Agronomiques

IPC: Integrated Food Security Phase Classification

LU: Livestock Unit

MAM: Moderate Acute Malnutrition

MCBS: Missionary Congregation of the Blessed Sacrament Society

MCM: Moderate Chronic Malnutrition

MSRI: Modified System of Rice Intensification

NB: Non-Beneficiary Families

NER: North East of India Region

NGO's: Non-Governative Organizations

NN: Nearest Neighbour

NNS: Normal Nutrition Status

OCHA: United Nation Office for the Coordination of Humanitarian Affairs

OV: Overweight

PC: Pilot Centre

PoU: Prevalence of Undernourished

PSM: Propensity Score Matching

PSM: Propensity Score Matching

PUN: Undernourishment

RPSP: Poverty Reduction Strategy Paper

SA: South Asia

SAM: Severe Acute Malnutrition

SAPs: Structural Adjustment Programme

SCM: Severe Chronic Malnutrition

SDG: Sustainable Development Goal

SSA: Sub Saharan Africa

SUTVA: Stable Unit Treatment Value Assumption

UN: United Nations

USAID: United States Agency from the American People

WAZ: weight-for-age z-score

WB: World Bank

WFP: World Food Programme

WGH: West Garo Hills

WL/HL: weight-for-length or height-for-length

1. Introduction

Poverty, rural population and food insecurity are, very often, topics related to each other (FAO et al. 2019). In this research, a project targeted to the reduction of food insecurity among poor rural population in developing countries will be analysed.

Poverty and rural population

According to the World Bank, the global poverty estimate in 2013 was around 10.7 per cent of the world's population, that is roughly 767 million people (World Bank 2016). Among the most vulnerable poor and food-insecure people, there are poor urban and non-farm households with a high share of food expenditures (Anríquez, Daidone, and Mane 2010) and those who depend on agriculture for their livelihood and income (FAO 2016). In 2013, the poor people were estimated at 388.7 million in SSA (Sub-Saharan Africa) and 256.2 million in SA (South Asia) (World Bank 2016). Roughly 80% of the poor live in rural areas (613.6 million), and 64% are working in agriculture (490.1 million). Applying these percentages to the poor people that are living in SSA and SA, it is possible to estimate that in SSA 311 million people are living in rural areas, and 248.8 million are working in agriculture; meanwhile, in SA 205 million people living in rural areas and 164 million people are working in agriculture.

The number of family farms in developing countries is also significant. Lowder et al. (2016) estimate that there are roughly 570 million farms worldwide, of which some 500 million are family farms. More than 475 million farms are less than two hectares (ha), which are considered as small family farms. Meanwhile, 410 millions of farms have less than 1 ha (Lowder et al. 2016). In SSA and SA, about 70-80% of farms are smaller than 2 ha and operate about 30-40% of the land (Lowder et al. 2016). A large part of these farms runs subsistence agriculture.

Thus, since many poor people are living in rural areas, and their first source of income is agriculture (especially subsistence agriculture), as well as is their first source of food, investing in agriculture seems an excellent option to cope with food insecurity in developing countries (Zezza et al. 2008).

The role of agriculture in fighting poverty and food insecurity

Agriculture has a direct impact on household food security and nutrition through three pathways, which are own production, agricultural income, and women empowerment (Jones et al. 2014, Carletto et al. 2015).

Small family farms account for up to 80 per cent of food produced in South East Asia and Sub-Saharan Africa, while supporting livelihoods of roughly 2.5 billion people (IFAD 2016). These farming households consume primarily what they produce. Thus, with more favourable nutrition-sensitive agricultural policies and empowerment of women, it could be possible to improve nutritional status (Pandey et al. 2016), for example through home production of nutrient-rich food crops. This could be achieved through two steps, namely diversification of production and introducing improved staples. In the early steps of development, in order to escape from subsistence agriculture it seems reasonable that diversified agricultural production would lead to more diverse diets and improve nutritional outcomes. That could be achieved pursuing the diversification of agriculture production towards fruits and vegetables, as well as animal husbandry, and integrated agriculture-aquaculture. The second step would be the introduction of improved staples and homestead gardens. However, most farming households already practice some mix of subsistence and market-oriented production, thus adding complexity to the relationship between farm production diversity, both plant and animal production, and dietary diversity (Jones et al. 2014). However, diversification cold be a problem to face, due to the increase of knowledge and input to collect and put in the production.

The second mechanism which enables agriculture to influence diets is their economic capacity to providing for income and generate expenditures, and modify the relative food prices; this could partly explain observed dietary changes in recent decades (Kadiyala et al. 2014). However, using agriculture as the basis for economic growth in the agriculture-based countries requires a productivity revolution in smallholder farming (World Bank 2007). Smallholders farming still operating in a subsistence-oriented production environment, where market access is strongly limited, hardly contribute to this general productive improvement (IFAD 2016). Under these strains, the agricultural systems face significant challenges to meet the demand for food, feed and other commodities, thus compromising food security in several areas (IFAD 2016).

Despite this constrains, according to Christiaensen et al. (2011) improving agriculture is still a significantly effective strategy in reducing poverty, and therefore food insecurity, among the poorest of the poor, at least when societies are not fundamentally unequal. Indeed, rural development is one of the most reliable and powerful forces for poverty reduction and broad-based social and economic development. Because this can happen at best, a smarter, more innovative, better focused, and cost-effective approach is needed (Fan and Brzeska 2016). Rural development is also essential for structural transformation (IFAD 2016), primarily if it is shaped by the interlinkages between agriculture, the rural non-farm economy, services and manufacturing. In this context, the role of public actors, as leader of the transformation is crucial. To support this consideration, IFAD points out that agricultural research, education, and rural infrastructure are the three most effective public-spending items for promoting agricultural growth and poverty reduction throughout the periods under study (IFAD 2016).

These considerations have found their place in the international debate. To cope undernourishment problem, the UN adopted in 2015 the "2030 Agenda for Sustainable Development" (United Nations 2015), that led to the proposal of 17 Sustainable Development Goals (SDG) in 2016. Such SDG is encompassing a wide range of goals, among which goal 2, the Zero Hunger (United Nations 2016).

The agenda set goals to reach in a different step. By 2020, the Zero Hunger goal aims to increase the investment, "through enhanced international cooperation in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks" (United Nations 2016). Also, the conservation of genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species are considered strategic for agricultural productivity, along with the promotion of access to fair and equitable sharing of benefits arising from the utilisation of genetic resources and associated traditional knowledge (United Nations 2016). From the market point of view, it is appropriately set in action to "correct and prevent trade restrictions and distortions in world agricultural markets, as well as adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves" (United Nations 2016).

By 2030, the Zero Hunger goal aims to: "end hunger and ensure access by all people [...] to safe, nutritious and sufficient food all year round and stopping all forms of malnutrition. From production, the goal is to double agricultural productivity and incomes of small-scale food

producers, […] through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment" (United Nations 2016). This production improvement must be ensured through sustainable food production systems and the implementation of resilient agricultural practices (Kadiyala et al. 2014).

So far, it is commonly accepted that agriculture plays an essential role in enacting food security, through diet improvement and rural population development. However, the precise role and mechanisms on how agriculture can do it in some developing countries remain debated. The data gaps for linking agriculture and nutrition have been previously identified as a problem and integrated datasets are required for understanding these linkages to leverage them for improving nutritional outcomes (Pandey et al. 2016). According to Kadiyala et al. (2014), the deep causes of these gaps include an interdisciplinary disconnection between nutrition and economics/agriculture, a related problem of inadequate survey data, and limited policy-driven experimentation. Therefore, closing these gaps is essential to strengthening the agriculture sector's contribution to reducing undernutrition (Kadiyala et al. 2014). In this research we tried to close some data gap in two areas were data gap are significant, namely Meghalaya State in India and Lomami province in the Democratic Republic of Congo, as well as to provide some evidence on how to improve food security through the intervention proposed in the "Production of appropriate food: sufficient, safe and sustainable" (C3S) project carried out by Università Cattolica del Sacro Cuore and presented in Chapter 4.

Hypothesis

Thus, the hypotheses under investigation are:

  a) the project has been able to enhance the food security among smallholder families that are involved in the project in Darenchigre, Meghalaya State, India; and

  b) the project has been able to enhance the food security among smallholder families that are involved in the project in Kabinda, Lomami Province, Democratic Republic of Congo (DRC)

To enquiry the hypothesis (a, b), two assumptions have to be taken into consideration:

  i) the project C3S has intervention or strategies able to affect the food security level of smallholder families

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and

ii) it is possible to collect sufficient information to describe the nutritional status, food production, foodstuff conservation, economic and social situation both in India and the Democratic Republic of Congo and evaluate the impact of the project.

Thus, to test the two hypothesises (a, b), the following sub-hypothesis linked to the assumptions (i, ii), for both India and DRC, have to be tested:

1. The project has strategies to improve the availability of food;
2. The project has strategies to improve access to food;
3. The project has a significant impact on food availability;
4. The project has a significant impact on food access;

Research design

The research is organised in three-part. The first part was exploratory and constitutes the theoretical foundation of the research. It aimed to review the literature on food security, food production and food supply chain in general, along with nutritional and economic information on the current situation both in India and DRC. The outcome of the theoretical foundation are the research objectives, hypothesis and the information which are contained in chapter 2, 3 and 4. In chapter 2, the state of the art on worldwide food security situation, along with the focus on the two areas under investigation, namely India (Darenchigre) and Kabinda (DR Congo), is presente. Definitions and models of food security program are presented and chapter 3, highlighting the problems related to measuring food security. In chapter 4, the theoretical model and ethics of the C3S project are discussed, focusing on the specific intervention made for families in Darenchigre and Kabinda.

The second part of the research is on the implementation of the tools used, the collection of information on the ground, which compose the empirical part of the study. The study is modelled following an ex-post evaluation on non-experimental setting design, and it was conducted on the field between November 2016 – February 2018. This information is presented in chapter 5. The last part is related to the statistical analysis and the hypothesis test. The results are presented and discussed in chapter 6 for India and chapter 7 for DR Congo. The conclusions are presented in chapter 8.

2. State of the art on Food Security. Worldwide, India and DR Congo

Food insecurity is widespread among poor people around the world, especially among those living in rural areas of developing countries and those employed in agriculture. Globally the number of undernourished people is growing due to the growing population and the stability or reduction of yield. To achieve global food security is essential to improve food security among the rural community through improving agricultural production. In this chapter will be present the worldwide situation, using data mainly from FAO research (2.2). Then, we will shift our attention to Asia and Africa. In 2.3 will be discussing the food production, the rural development issues, and the perspective from the general context of India moving to the North East Region (NER) till the Meghalaya State – Darenchigre. Same structure has been followed for 2.3, where the focus is the Democratic Republic of Congo, Lomami Province, Kabinda.

2.1. Food Security Background

Food insecurity is still a severe problem in large part of the world, and the forecast on growing population and food production calls for an intervention. According to the Food and Agricultural Organisation of the United Nation's (FAO), in 2050 the global food demand is projected to increase by at least 60 per cent above 2006 levels (FAO 2016).

Population and income growth, as well as rapid urbanisation in areas where we register the highest prevalence of undernourishment and high vulnerability to the impacts of climate change, are driving this increase (UN and OCHA 2017) is the principal driver of food insecurity problems.

According to the estimation of FAO in 2016, roughly 784 million people suffered hunger. Breaking down hungry people by region, 4.7 million lives in USA and Europe, 232.5 million in Africa, 511.7 in Asia, 34.3 in Latin America and Caribbean and 1.4 in Oceania. In the *State of Food 2019,* the number estimated of worldwide hungry people rose to roughly 820 million from 775 million people in 2014 (FAO et al. 2019). The worldwide trend and situation have been photographed by the Prevalence of Undernourished (PoU) and the Food insecurity Experience Scale (FIES), which are the indexes used for measuring the Sustainable Development Goal (SDG) proposed by the United Nation (FAO et al. 2019)[1].

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[1] Both PoU and FIES indexes will be presented in chapter 3 among the measures of Food Security.

The number of undernourished people and the PoU index is shown in table 2.1, while in table 2.2 has been presented the situation in Sub Saharan Africa (SSA) and Southern Asia (SA). Both tables cover the trend for the last 16 years. Globally, the percentage of people that suffered undernourishment decreased between 2000 and 2015 (mainly between 2005 and 2010), while in 2016 the trend is inverted (FAO et al. 2019). It is possible to observe that per each year, the situation in SSA and SA is always worsened than the average reported for the reference region.

The food security situation has visibly worsened in parts of SSA, South-Eastern and Western Asia mainly for conflict situation, droughts and floods, other than economic issues, such as economic slowdown and drained foreign exchange and fiscal revenues that are affecting both food availability (due to import-export activity) and access (FAO et al. 2017, 2019).

Table 2.1 Prevalence (%) and number (million) of undernourished people in the world, 2000–2017 (modified FAO et al. 2017, 2019)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
%	14.7	14.8	14.9	14.9	14.6	14.5	13.5	12.8	12.3
million	900.0	917.5	936.3	947.2	941.7	926.0	890.9	854.5	831.8

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
%	11.9	11.8	11.2	11.0	10.8	10.7	10.6	10.7	10.8
million	814.7	794.6	782.1	779.3	775.4	775.4	785.4	796.5	811.7

Table 2.2 Prevalence of undernourishment (%) in the World, Africa, SSA, Asia, SA, 2000 – 2017 (modified FAO et al. 2017, 2019)

	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
	Percentage									
World	**14.7**	**14.5**	**11.8**	**11.2**	**11.0**	**10.8**	**10.7**	**10.6**	**10.7**	**10.8**
Africa	24.3	21.2	19.1	17.9	17.8	17.8	18.1	18.3	19.2	19.8
Sub Saharan Africa (SSA)	*28.1*	*24.3*	*21.7*	*20.2*	*20.0*	*20.0*	*20.4*	*20.9*	*22.0*	*22.7*
Asia	16.7	17.4	13.6	12.8	12.5	12.2	11.9	11.7	11.5	11.4
Southern Asia (SA)	*17.7*	*21.5*	*17.2*	*15.9*	*15.9*	*15.7*	*15.3*	*15.7*	*15.1*	*14.8*

According to the Food insecurity Experience Scale (FIES) (FAO et al. 2019), in 2017 in SSA 25.8% of people suffer for severe food insecurity, meanwhile the percentage of severe food insecurity rise to this percentage rise to 32%. The situation is appearing less dramatic in SA,

but still, 10.8% and 17.3% suffer for moderate and severe food insecurity, respectively, in 2017.

The result of these two indexes is diverse. This should not surprise, because they rely on two different datasets. PoU index employs official country data and demographic characteristic of the population, while FIES use a direct interview with adult people. Thus, these two indexes capture different situations: FIES reflect short-term fluctuations in countries' economic and social conditions obtained by the survey on subsamples in whole countries, while PoU estimates might not reflect recent changes in access to food.

Another critical index that should be taken into consideration to describe the food insecurity is the Global Hunger Index[2] (GHI). The GHI is a tool designed to comprehensively measure and track hunger at global, regional, and national levels (von Grebmer et al. 2017). In the Democratic Republic of Congo (DRC), unfortunately, only three out of four indicators are available, so it is not possible to calculate GHI. DRC's indicators are PUN[3] (not available), CWA[4] 8.1%, CST[5] 42.6%, and CM[6] 9.8%. India strongly influences South Asia's regional score, given that three-quarters of South Asia's population is living there. India's 2017 GHI is 31.4, meanwhile in 2008 was 35.6. Indian's indicators are PUN 14.5%, CWA 21%, CST 38.4%, and CM 4.8%.

Moving to the side of production, it is well known that family farms produce roughly 80% of food value production. That statement is true but usually is misunderstood because of the meaning of family farms.

According to FAO (FAO 2014a), family farms are defined according to the type of management. In facs, this type of farms is defined as:

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[2] GHI scores are based on four component indicators: undernourishment, child wasting, child stunting, and child mortality.

[3] UNDERNOURISHMENT (PUN): the share of the population that is under-nourished (that is, whose caloric intake is insufficient);

[4] CHILD WASTING (CWA): the percentage of children under the age of five who are wasted (that is, who have low weight for their height, reflecting acute undernutrition);

[5] CHILD STUNTING (CST): the share of children under the age of five who are stunted (that is, who have low height for their age, reflecting chronic undernutrition);

[6] CHILD MORTALITY (CM): the mortality rate of children under the age of five (in part, a reflection of the fatal mix of inadequate nutrition and unhealthy environments).

"all family-based agricultural activities which are linked to several areas of rural development. [Thus,] Family farming is a means of organising agricultural, forestry, fisheries, pastoral and aquaculture production which is managed and operated by a family and predominantly reliant on family labour, including both women's and men's" (FAO 2014a).

According to FAO (FAO 2014b), 90% of worldwide farms are family farms (513 million). They covered around 70/80 % of the agricultural land (roughly 516 million ha), so it is reasonable to assume that these farms can produce up to 80% of worldwide food value. However, in developing countries, the most common type of family farm is the small family farms, that cultivates less than 2 ha of land. These farms are up to 84% of the total number of farms in developing countries. Considering the average extension of a farm, this means they cover only 12% of worldwide agricultural land. So, this type of farms cannot be considered responsible for a significant amount of worldwide food production. However, this consideration changes drastically when we move to the rural areas of developing countries. These farms, because they are very often dedicated to subsistence agriculture, play a strategic role in the fight against hunger.

Food security, or insecurity, is originated from a different situation, depending on the region. Because India and Democratic Republic of Congo are very different in terms of context and problems, in the next two sub-chapter will be presented the current situation in these two countries separately.

2.2. Republic of India

India is facing a severe nutrition problem, as stated by FAO (FAO et al. 2017). The reduction in undernourishment[7] has been slow despite the recent strong economic growth (Banerjee 2014). As a consequence, India's Global Hunger Index (GHI) has fallen from 80th to 97th since 2000 (von Grebmer et al. 2017; Ritchie, Reay, and Higgins 2018), till 103 in 2018 (GHI 2018). The problem of undernourishment in India is complicated, and determined by a combination of different issues: low efficiency of food supply chain in a context of climate change, substantial inequalities among people in terms of dietary intake and diversity, disease burden

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[7] Namely lack of proper nutrition, caused by not having enough food or not eating enough food containing substances necessary for growth and health.

(intensified by poor sanitation and hygiene standards), and low female empowerment and education, especially in nutritional fields (Bhutta 2016).

Economics

In India, where the agrarian sector accounts for the employment and income of a large percentage of the population, the impact of domestic food shortages due to agricultural prices and the balance within international markets is particularly pronounced (World Bank 2013), mainly if related to food import (Kadiyala et al. 2014). Nevertheless, closing Indian's current food supply and nutrition gap while meeting increasing population demand will require a combination of domestic measures to improve agricultural practice and subsequent yields, in addition to a well-planned increase in food imports (Ritchie, Reay, and Higgins 2018). The interaction between demand-side measures and supply, governmental policy, commodity prices and trade, creates a critical feedback loop for food pricing, affordability and production (Evans 2008).

Inequality

In the whole of India, and NER is not an exception, there are massive inequalities in the food supply and dietary intake. That is making hard to address the undernourishment challenges appropriately. Even in cases where average macronutrient supplies meet requirements, the high coefficient of variation in distribution among the population (even in the same household) still leaves a significant proportion of the total population at risk of malnourishment (Ritchie, Reay, and Higgins 2018).

Food production

Focusing on food production, due to the terrific increase of population, India cannot rely only on domestic food production: even in a highly efficient food system, achieving self-sufficiency is impossible based on actual production levels and the need to provide sufficient nourishment for all (Ritchie, Reay, and Higgins 2018). Focusing on the North East Region (NER), by the year 2050, the total food grain demand would go up to 13.28 million tonnes. Therefore, production should almost double using the same or (most probably) fewer land resources. (ICAR 2013). Increasing food grain production is critically important for improving food security, mainly because the population is growing by about 2% in this area of India (ICAR 2013). There are two possibilities to increase the amount of available food, namely enhancing food production and reducing losses.

From losses, India's food supply chain is facing a consistent amount of losses, especially during harvest, handling and storage. For example, at the level of storage, roughly 10-40% of food is lost due to pests and diseases (Shukla and Patil 2015). Notably, in NER the horticulture sector suffers heavy post-harvest losses (ICAR 2013). Even if horticulture and plant production should provide (in some period and condition) a surplus production, that surplus cannot entirely be provided to the market. Both fruits and vegetables are perishable commodities, and the lack of market availability within a reasonable distance from the production site, combined with poor road network, storage and transportation infrastructure, pose a significant obstacle to make it suitable for far market. A certain amount of reduction of losses and waste is achievable, but this would take significant economic, infrastructural and educational investments, and even 50% of the decrease in losses/waste alone would be mostly insufficient in ensuring food security in India. (Ritchie, Reay, and Higgins 2018).

Moving to the enhancing of food production, the main problem is the decreasing of cultivable land due to the increasing demand of land from other sectors (Das et al. 2014), as well as the increase of population. Therefore, additional food has to come from intensification of agricultural production (Sinha 2010). So, increased production should be focusing on closing the yield gap and on Sustainable Intensification (Mueller et al. 2012). Sustainable intensification relies on the capacity of farmers to adopt efficient agro-technologies, quality varieties of plants and animals, plant nutrition, proper irrigation and proper animal feeding under changing climate conditions. However, a substantial limitation in the adoption of such innovation is the before mentioned little amount of land per farmers. In facts, marginal and small farmers have less than 1 ha landholding size NER (ICAR 2013). In general, it is possible to highlight the following general consideration related to increasing food production in NER:

- Agro-technologies: the rice productivity in the hilly area of NER is very low due to traditional agricultural practices (based on continuous flooding, transplanting of aged seedlings mostly under random planting, inappropriate nutrient and weed management) along with cultivation of low yielding local varieties (Das et al. 2010, Kumar et al. 2015). Accordingly, modified SRI (MSRI[8]) was demonstrated to be more performing, reaching better production (Das et al. 2018). Energy and economic efficiency of agricultural practices throughout the NER are far from satisfactory. More

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[8] SRI: System Rice Modification; MSRI: Modified System Rice Modification

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than 80% of the operations are manual, and farm mechanisation is limited to certain pockets areas only (ICAR 2013);

- Supply of good-quality seed and planting material is inadequate (ICAR 2013);

- Water: Water-use efficiency of traditional rice-based cropping systems in NER is low and needs to be revisited (Das et al. 2018); That should be achieved through the yield increasing instead of the mere reduction of water use.

- Plant nutrition: farmers have trouble to produce or find farmyard manure for crop production (Das et al. 2010). This problem is severe, especially under organic farming rules, which is widespread in NER; Meghalaya is facing a severe problem, due to the Organic Farming Law, which allows only Organic farming practices. Very often the alternative is the non-fertilization;

- In pocket areas, due to lack of information and training, the farmers are adopting intensive tillage, more and more chemical fertilisers, more irrigation and excessive pesticides that have adverse impacts on soil health and productivity (Das et al. 2014);

- Production in animal husbandry, poultry and fishery sectors is much below the requirement. However, pig meat and poultry sectors are growing at a faster rate than the dairy sector. (ICAR 2013). Related problems are also the availability of safe and cheaper feedstuff of pigs, cattle and poultry;

- Climate change: this area is one of the most risk-prone for climate change impacts (Roberts 2001). In facts, it is expected an increase in the average temperature of 2 or 3°C (Ritchie, Reay, and Higgins 2018). Thus, continuous adaptation of climate change, through valorising the resilience of agricultural ecosystem, is strategic for the future.

Vision 2050

In 2013, the Indian Council of Agricultural Research formulated Vision 2050 document, which aims to provide a proposal for research to improve agricultural production in NER. Meghalaya State is in NER. The report is an assessment of the current situation, the trend in various factor and changes in the agricultural sector, setting a research agenda for science led to the development of agriculture (ICAR 2013). Vision 2050 wishes to be a holistic strategy at different levels, as national, international and regional programs level. It is focused on

integrated farming system replacing jhum[9] practices, changes in cropping pattern, increasing cropping intensity, enhancement of soil and water productivity, biodiversity utilisation, carbon management and trading, control of soil erosion, conservation agriculture, strengthening of traditional knowledge (ITKs), organic farming and diversification through agroforestry (ICAR 2013).

The most important lines of action look at making the region self-sufficient in food production are:

- Developing organic farming practices promoting in identified pockets with selected crops and commodities on a farming system mode to boost the economy of farmers, to put NER in a worldwide organic farming network (especially for cash corps); Not all the States in NER has adopted Organic Farming as an only food production system. For instance, Assam still allows the use of chemicals in food production.

- Reduction of the area under jhum practices and ensuring livelihood security of the Jhumias;

- Establishment of surveillance, detection and management of plant and animal diseases including the trans-boundary pests and diseases;

- Developing and optimise structural measures (mechanical, vegetative measures) to water harvesting and recycling, cropping system and crop geometry for in situ moisture conservation and enhancement of water productivity. It is set as a line of action, even if NE hill region receives an average annual rainfall of 2400 mm;

- Fishing can be implemented due to the richness of ponds and natural stream and river to enrich the diet on valuable proteins;

- Improving meat and meat product, egg and milk because the population has non-vegetarian habits and because these products will be less affected by remoteness and transportation cost;

- Improving the local breeds and development of crossbreed pigs, poultry (both eggs and meat), as well as dairy cows, to suit the local conditions and preferences;

- Screening of tuber crops, development of nutritive grasses, screening fodder trees to enrich the supply of feedstuff;

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[9] Jhum practices (shifting cultivation) are shifting agriculture practices, based on clearing and burning the vegetation. After few years of cultivation, when the productivity of the soil declining, the land is abandoned. When the land recover fertility, the process of clearing and burning start again.

- Providing better health management and animal vaccines to farmers;
- Valorising the biodiversity of NER: around 6000 rice lines, designated as ARC[10] rice genetic series, are used in the significant rice improvement programs of the world; about 50 % of the bamboo species of the country are available in the region. About 14 species of banana, 17 species of citrus. Wild relatives of 132 economically relevant species like rice, banana, citrus, mango and pulses have primary or secondary centres of origin in the region (ICAR 2013);
- Creating a robust agricultural information network system by reducing the distance between farmers, researchers, policymakers, business houses and entrepreneurs through active IT interfaces; providing an excellent extension service, training and transfer of technology for enhancing the spreading of technologies at field level and improve technology adoption. The creation of intermediate steps in this network system, such as the promotion of farmers groups or association, can make easier achieve the process goals.

India is facing an increase of population and, at the same time, a reduction in cultivable land, also experiencing a growth in yields that is lower than the growth in the population's food needs. Being aware of these problems, NER Indian researchers list issues and actions to face this problem. Meghalaya State has chosen to cope with this problems implementing Organic Farming practices. While in NER, the agricultural bodies are trying to shape the future of food production, the same will cannot be found in DRC. In the next section, will be presented the current DRC situation, focusing on the area where the project C3S is working.

2.3. Democratic Republic of Congo

The Democratic Republic of Congo (DRC) has struggled with one of the world's most relentless emergencies for decades (von Grebmer et al. 2017).

2017 was one of the most violent years in DRC's recent history. As a consequence, more than 5 million people have forced to flee their homes. Mass displacement, malnutrition and epidemics, such as Cholera and Ebola outbreaks, have scoured the nation. Conflict and

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[10] Type of Rice genetic line

insecurity, which limit access to livelihoods and disrupt farming activities, are critical drivers of food insecurity, especially in the north-east and in the higher Kasaï regions[11] (ACAPS 2018). According to OCHA[12] (UN and OCHA 2018), as of June 2018, in all DRC 7.3 million people are estimated in severe food insecurity, a significant increase from June 2017 (5.9 million), and June 2016 (4.5 million).

Focusing on East Kasaï Region, which the area were we operating our research, the Lomami Province was part of, the food security situation is alarming: 1.9 million people require assistance (ECP and HAO 2018). The situation got worse because in 2017 escalating conflict displaced 1.4 million people (von Grebmer et al. 2017).

According to IPC[13] classification (USAID 2012), Lomami Province is classified under "stressed" label[14]. A series of negative factors are challenging food security, as recurrent conflict and subsequent internal displacement of persons, lacking improved agricultural inputs and techniques, pervasive crop and livestock diseases, inadequate physical infrastructure, the gender inequity, and a high fertility rate (USAID 2016b).

Food production

The DRC's economy is dominated by the agriculture and forestry sector, creating 30% of GDP in 2009 (Jeníček and Grófová 2015). According to the Democratic Republic of Congo Staple food market fundamentals (USAID 2016b), staple foods are produced mainly by small-scale producers. The primary agricultural technique used in the Lomami Province involves savannah clearing and burning, followed by cropping for two to three years before leaving a current field due to decreasing soil fertility. This technique is called slash-and-burn or shifting cultivation. Usually, farmers come back after 7-8 years (nowadays reduced to three-four years, because of population growth and general yield reduction) waiting for restabilising of soil fertility, whereby families have under their purview up to ten or more fields, most of which are fallow. Soil fertility is an important issue. Generally, the soil is ferralsols type whit a low organic matter percentage and low nutrient reserves (Muyayabantu, Nkongolo, and Kadiata 2013). This basal condition, along whit very short fallow, small or no-fertilisation (both organic or inorganic),

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[11] In 2015 Kasaï Occidental and Kasaï Orientale were split into the following provinces: Kasaï, Kasaï Central, Kasaï Oriental, Sankuru, and Lomami
[12] OCHA: United Nation Office for the coordination of Humanitarian Affairs
[13] IPC: Integrated Food Security Phase Classification
[14] The categories from 1 to 5 are: minimal, stressed, crisis, emergency and famine.

plus erosion of surface layer of soil, are leading the grounds to a consistent reduction of fertility, which is a crucial contributor to the decline of productions. As a consequence of the decline in yields, crops tolerant of poor nutrient soils are increasingly grown. Cassava is the most common example of it, and that happened despite its low quality for human nutrition. Agricultural inputs, such as chemical fertiliser, are not easily obtainable due to the cost (three-four times the cost in Katanga province, for instance), or due to the distance, which has an impact on costs itself. Furthermore, another crucial agricultural input such as improved quality seeds is available at the research station in Ngandajika (INERA, 95 km from Mbuji-Mayi). Unfortunately, this resource is easily not accessible to the majority of farmers in the Lomami Province. Generally, the cost of inputs will remain high until consistent and reliable fuel and other goods become less costly.

The staples crop generally cultivated are cassava, maize, legumes (including cowpeas, groundnuts, and other dried beans to a lesser extent), rice, plantains and palm oil. Households own poultry, goats, pigs, and very few cattle, but access to animal vaccines is extremely limited in the Province, and as a result, the livestock mortality rate is high (Akakpo et al. 2014). Due to the presence of freshwater, such as a river, fishing is quite important for food production, but not as income activity.

Logistics

The most common mean of transportation for agricultural goods is the bicycle. These "bicycle commerçants" carry loads of maize and rice and tanks for palm oil on Lomami's roads. Markets in the Lomami Province are much thinner than elsewhere in the country with minimal and weak linkages among markets (not appropriate marketing networks exist). That is due to the deplorable state of infrastructure (including but not limited to roads) and small-scale traders which together make it very difficult for commodities to circulate. Lack of road networks restrict trade with other provinces, and most trade occurs in two market sheds, one surrounding Kananga (Kasaï - Central) and a second surrounding Mbuji-Mayi (Kasaï - Oriental) (USAID 2016a).

Infrastructure

The physical isolation of the Lomami Province from the rest of the country is reflected in the deterioration of or lack of infrastructure. The deeply eroded or non-existent infrastructure has both direct and indirect effects on agricultural production and marketing (including

transportation, processing, and storage, among others). The principal road, the National Road number 2, was paved in 1976 with some more recent maintenance. Also, electricity has minimal availability and strong dependence on electric generators. Lack of infrastructure and lack of access to services constrains development progress in all sectors and contributes to some of the highest poverty rates and most mediocre nutrition and health outcomes in the country (USAID 2016a).

2.4. Summary

The number of people that suffer from food insecurity is rising, after a short period in which this number had fallen. In 2018, FAO et al. (2019) estimated that still 821 million people suffered undernutrition, of which 239.1 million are in SSA and 278.5 in SA. In this chapter, we presented the general situation in the areas where the project is operating. The Indian's situation is getting worse due to the increase in population and the difficulty to enhance food production. The primary concern in Meghalaya is to provide food with less environmental footprint. This approach led the authorities to adopt Organic Agriculture as a productive system. This approach seems to cast some doubt, especially in terms of the potential increase in production. In DRC, the main problem is lack of infrastructure, which pose a significant problem to outline a proper development project. Among general shortage of infrastructure and services, people are struggling between endemic corruptions, political instability and indigent health care system. In this contest appear urgent to increase the food security condition to those relays on agriculture for living. Meanwhile for India, it was easier found documentation about subsequent development in rural areas, from production to the non-farm income, in DRC we do not find any evidence.

That highlight once more that the social and political will are determinant to general development and the lack of it casts a long shadow on the overall quality live improvement and, thus, the food security. This last consideration brings the need to present how the Food Security concept has been shaped through history and how agencies and international bodies tried to measure food security or insecurity. These topics will be presented in the next chapter.

3. Definitions and models of Food Security programs

This chapter presents the definition of Food Security (FS), the evolution of the FS approach from WWII until the second decade of the new millennium and the main indexes to evaluate FS. The chapter is organised as follow: in paragraph 3.2, the topic of food security will be discussed from a historical point of view, the socio-economic implications and the effects on development models in developing countries. Paragraph 3.3 presents the concept of food security, the evolution, and the correlated four dimensions: production, access, utilisation, and stability. Paragraph 3.4 we will focus on the current index utilised to quantify food security, paying particular attention to the construction of the indexes. Paragraph 3.5 will be briefly discussed the criteria to evaluate the goodness of food security indicator.

3.1. History of Food Security

The evolution of FS interventions is quite complex, principally due to the plurality of subjects involved in it and the meaningful shifting of ideas occurred from the end of WWII till the first decades of the new millennium. A systematic approach that highlights dominant and subsidiary ideas and what kind of impact these actions had in rural areas has been addressed, among other authors, by Ellis and Biggs (2001), Moyo (2009) and Sassi (2018).

Ellis and Biggs have articulated an overview of the significant developments in rural development theory that has occurred from the 1950s to the early new millennium. They articulated the analysis in six sub-periods:

- The 1950s to 1960s: from community development to the emphasis on small-farm growth;
- The 1970s continuing small-farm growth within integrated rural development;
- The 1970s to 1980s from state-led rural development to market liberalisation;
- The 1980s and 1990s process, participation, empowerment, and actor approaches;
- 1990s emergence of sustainable livelihoods as an integrating framework;
- The 2000s mainstream rural development in poverty reduction strategy papers.

The authors concluded that agriculture would be sustained more through service to increase productivity (as research, extension, credit, and input) than the development of a start-up environment for entrepreneurs. However, such an environment could be an occasion to increase the chance to expand (in variety and range) the non-farm income of the rural poor population. Thus, cross-sectoral and multi-occupational diversity of rural livelihood, which

takes into account farm and non-fam income, should become the point of view through which implementing rural development policy.

Moya addressed the analysis of aid in Africa, which was mostly focused on food security, from the middle of WWII until the first decade of 2000. She proposed an analysis per decades:

- 1940s Bretton Woods
- 1950s Marshal Plan
- 1960s Industrialization
- 1970s shift towards aid as an answer to poverty
- 1980s aid is the tool for stabilisation and structural adjustment
- 1990s aid as a buttress of democracy and governance
- 2000s aid as a solution for development problems of Africa

Moya states that development plans based on the preponderant aid component had a series of negative consequence on the development itself. First of all, aids generally do not promote an environment for entrepreneurs. Instead, they have developed a culture of aid dependency. Development plan with an aid component should be oriented to acquire goods and service in loco, such as buying food from local producers and distributing that food among poor population instead of importing food from rich countries.

Sassi proposes a similar decade-division suggested by Moya but mainly focused on food security issues, underlying the relationship between the political approach to the problem and the disposed operative solutions:

- The 1940s and the concern about the physical availability of food
- The 1950s and the self-sufficient and surplus disposal
- The 1960 and Agricultural production technique progress and assistance in Economic development
- The 1970s and the shocks
- The 1980 and the lost decade
- The 1990 and the food as a tool for managing the emergence
- The new millennium and the food crises.

Sassi highlights how to address hunger issues, a robust political will should be necessary, along with strong government institutions which embody the commitment of reducing food insecurity. The locus of responsibility has to shift from the national to the local level. Because that change could happen successfully, adequate know-how and financing should be guaranteed.

To understand the actual framework of food security intervention, it is useful to retrace the central fact and ideas that shaped the intervention, following the reason proposed by Moya and Sassi. Thus, in this section, each decade has been illustrated briefly per context, ideas, and intervention.

The 1940s. Growing concerns on Food Availability
WWII had a profoundly negative impact on food production on a global scale. Thus, On 16 October 1945, the United Nations (UN) established the Food and Agricultural Organization (FAO). UN conferred to FAO the task of supporting agricultural and nutrition research, as well as providing support to the countries to boost agricultural (comprising forestry and fisheries) production. From production, some relevant change happened. In the late 40s, the food production in Asia worsens, which passes from a traditional food surplus area to a net import region (Sassi 2018). Africa, on the other hands, was perceived as a continent ready to develop, considering the opportunity in terms of agricultural and economic production. Thus, the actions were dedicated to the production ground, as well as food transfer, price stabilisation policies, in view of a growing trust in technological progress. In the same period, the worldwide population number began to rise, starting the race between population growth and food production.

The 1950s. Industrialisation as a development engine
In this period, the developed economies are recovering from the damages that occurred during the war. The prevalent growing strategies were based on government-led industrial growth, while agriculture was intended as a resources reservoir (FAO 1995). At the same time, the demand for goods raised, especially those exported by the USA. This request triggered a scarcity of Dollars, which prompted a payment crisis in the developing countries. Most of these countries were net food importer, which had to set up a severe restriction on food import. To balance the situation, these countries adopted a self-sufficient strategy focused on development plans and the national availability of food were taken into account as the most important indicator of food security. From the side of agriculture in developed countries, in the same period a substantial food surplus has been registered. Therefore, the issues about how to use this surplus without distorting the market became very important. Food aids than became an essential instrument of foreign policy for both US and URSS (Moyo 2009) and

became the most relevant instrument to achieve FS (Sassi 2018). At the end of the 1950s, the concerns on hunger raised as a consequence of the failure of the "Great Leap Forward." This failure caused a dramatic food shortage in China, where 20 to 30 million people perished between 1958-1961.

The 1960s. Modernisation theory

Since after WWII, the focus was to increase food availability through the modernisation of agriculture recurring to high input strategies. These initiatives were the backbones of the Green Revolution. In this period, many efforts have been made to develop and transfer to significant farm agricultural technology and tools, such as fertiliser and mechanisation, and improved varieties of cereals. The underlying idea was that spreading technological efforts would have increased agricultural productivity, boosting food supplies entailing a reduction of food prices and improving food access with an overall improvement of the quality of life, especially in rural areas. The theory nowadays knew as "modernisation theory", prompted the application of capitalism and technology to move from underdevelopment to development, especially in developing countries. In this contest, large farms would be the first adopters of innovations, while later spread among small farmers due to imitation. Another essential theory which should be mentioned is the revival of the neoclassical approach at the international market, which would favour the export-oriented cash crops instead of food crops for the local population. This approach paid insufficient attention to the local production scale and the needs of the poorest people. At the beginning of the decade, FAO and UN created the World Food Programme (WFP), with the purpose of using the surplus of food as aid for economic development in developing countries, as well as fighting hunger and malnutrition. However, the first approach to ensure food security remains the increase in food production in developing countries.

The 1970s. State intervention

This decade was characterised by several economic and wheatear-related shocks which affected the international order and consequently the food production. Two oil shortage (72-73 and 79) leads to energy crises which produced many adverse effects, such as the cereal prices increase, the reduction in tropical agricultural commodities, the increase in volatility of world financial market. Moreover, severe weather condition occurred between the 72 and the 74 affected the food production severely, especially in Africa ('73 Sahel, '72-'74 Ethiopia).

So, emergency food reliefs and price stabilisation policies were implemented to cope with these dramatic situations. In 1970 the International Fund for Agricultural Development (IFAD) was established during the World Food Conference to finance agricultural development project in developing countries.

Along with food production in this period start to be taken into consideration also the economic access to food. This paradigm extension has resulted in taking the initiative to reduce the underemployment in rural areas, also expanding the off-farm income-generating activities (IGA), as well as those to increase equity, distribution of wealth, and political power. Unfortunately, growth with redistribution focused on a small farm did not produce significant effects (Lemba 2009), most of all, because of the inefficiency of government and bureaucracy (Rondinelli 1993).

The 1980s. Market Liberalization

After the second oil crisis, many developed economies put in place strict monetary and fiscal policies with a consequent increase in real interest rates, reduction of economic exchange, especially for the goods produced in developing countries. The situation degenerated until the point to a considerable deterioration in balance sheets of developing countries which were not able to access the monetary credit. The global response was a mix of neoliberal policy based on structural adjustment of economic policy in developing countries. The International Monetary Fund (IMF) and the World Bank (WB) propose the so-called "Structural Adjustment Programmes" (SAPs), which allowed developing countries to obtain further credit.

Meanwhile, the focus on small farmers remains predominant. Concepts as "participation" and "sustainability" emerged in the SAPs (Ellis and Biggs 2001). For the ground of participation, the intervention approach shifted from "top-down" to "bottom-up" (Rondinelli 1993). The theme of "sustainability" was largely enquired by many researchers, starting from the works of Sen (1981). In this context, the non-farm sources of income had been taken into consideration as a crucial issue to the achieve household FS (Lemba 2009). Within the context of sustainability, the intervention is focused on each pillar: social, economic, environmental, political (or structural), as well as the technological issues (e.g., appropriate to the context) (Lemba 2009), without neglecting capacity building and local leaders training. However, this approach, while promoting agricultural activity in rural areas, left in the background the other non-farm jobs, missing to create a dynamic environment for non-farm activity. Instead, that could have expanded the opportunity for rural people to build their livelihood (Lemba 2009).

This consideration is also supported by Ellis and Biggs (2001), which deem that rural development should consider agriculture at the same level along with other rural and non-rural activities, as essential part to build a viable rural livelihood (Ellis and Biggs 2001). From the agricultural point of view, only big farms have benefited from these policies, because they were already connected to the global market. For other smallest farmers, especially the poorest, which were not connected to the global market, this approach led to an increase in prices for inputs (seeds and other tools) and income losses due to the reduction of the sale revenues (Sassi 2018).

The overall effected of these programs were therefore criticised, due to the few successful cases and the high social cost for the poorest.

In this context, the general approach to food security changed, led by the change in academic perception of the food insecurity phenomenon. Researchers as Sen demonstrated that adequate food availability at the national level does not mean food security at the household and individual level (Sen 1981). Thus, the definition of food security was enlarged, considering the fundamental role of food availability, supply stability, access to food, and more recently, the nutritional diet requirement (appropriateness).

The 1990s. Global Summits on Food Security

In this decade, several financial crises affected Asia, Latin America, and the Soviet Union (which eventually collapsed). Because the neoliberal approach, based only on the market, was not able to solve the problem that leads to the financial crises, addressing the market imperfection and targeting the poverty eradication appeared urgent. Thus, the concept of development was considered as a comprehensive process based on people and their needs (Sassi 2018). To meet this new paradigm, developing countries were called to prepare the Poverty Reduction Strategy Paper (RPSP). Very often in this RPSP, agriculture and rural development become a direct area for the poverty reduction process.

Along with considering the same importance for farm and non-farm activities to develop rural areas, two new concepts arise after the '90s: "globalisation" and "new modernisation". Globalisation is, at the same time, an opportunity and a challenge. Opportunity because exposing nations to technologies and jobs, which could improve incomes and reduce poverty, may positively influence the food security status (FAO 2004). On the other hand, globalisation, through their mechanisms, could isolate and marginalise individuals, families and communities (Murphy 2000), other than changing the social and economic context rapidly.

This rapid changes sometimes lead communities in confusing and painful transitions affecting who is unable to utilise the opportunities offered by globalisation (Lang 2003). The mechanism that addresses the marginalisation due to globalisation is encompassed in the concept of "new modernisation". A vital aspect of this theory is the market-led research, in which farmers work in collaboration with national or international research institutes, along with the private sector, to produce goods according to the market demand (Lemba 2009). This model has a precise hierarchal structure of intervention (Dorward et al. 2004), as shown in Table 3.1.

Table 3.1 Policy phases to develop agricultural in favoured areas (modified by Dorward et al. 2004)

Phases	Intervention	Attended Output
Phase 0		extensive, low productive agriculture
Phase 1 Establishing the base	Roads, irrigation, research, extension, land reform	profitable intensive technology; uptake constraint by inadequate finance; input and output market
Phase 2 Kickstarting markets	Seasonal finance Input supply Reliable local output market	Effective farmer input demand and surplus production
Phase 3 Withdrawal	Effective private sector market	The large volume of finance and input demand and output supply; Non-agricultural growth linkages

In the first phase, the focus is on addressing the necessities, such as infrastructures (roads), administrative access to goods (land), and connecting scientific research to farmers. In the second phase, the focus shift to the market needs, such as communication and institutional environment: e.g., credit access, contracting, facilitating agreements, and other measures that put the actors in conditions to take strategic and economic actions. In the last phase, the intervention in input and credit that facilitates the kickstart phase are withdrawn, in order to make the demand for these goods and services market-oriented. In this phase, the linkage with non-agriculture activities is favoured. It is important though that the external intervention happens in an appropriate condition. Otherwise, the simple capital injection makes the situation worse (Moyo 2009; Deaton 2015; Nzamujo 2016).

Along with the changes already mentioned, the 1990s were characterised by the high number of global summits, where NGOs (Non-Government Organizations) and CSOs (Civil Society Organization) played an essential role in the international debate. NGOs and CSOs advocate for a democratic and fair form of land ownership, self-communities control over the land use, access and use of water resources. That means involving the communities themselves in the

decision on food-related issues, infrastructure and facilities (transportation, storage) promotion, enhancing the full participation of people in the economic activities. On the other and, themes as sustainability biodiversity and improving traditional knowledge (through preserving and reinforcing) emerged in the developing agenda.

The 2000s: Food crises and political turmoil

High and volatile food prices, along with the economic recession, financial and social turmoil, characterise the contest of new millennium. In 2008 a severe food crisis took place starting with shocks in grains prices which lead to social crisis in several States. Among the factors which triggered the crisis have to be mentioned a reduction in cereals production and the restriction of cereals export along with financial market speculations. Therefore, the high food price problem started. The crisis was very aggressive in developing countries, especially among food net importers. Households have suffered cumulative stress, which eroded the coping strategy and widening the number of those who have fallen below the poverty line. Plus, families that have already allocate a massive part of income in food supply found themselves in the conditions of no longer sustain the expenses for school, which means eroding human and economic capital at the national level. In this context, because most of the pour people live in rural areas, operating with small farmers to develop a sustainable small-scale local and resilient food production became strategic. Targeting rural producers means enhancing the quality of lives of rural families. So, agriculture and rural development are recognised as critical factors to achieve FS and poverty reduction. From the policy point of view, also the approach to food security issues changed. Countries introduced three types of policy (Sassi 2018):

- Trade oriented policies to reduce prices or increase domestic supply
- Consumer-oriented policy to support consumers and vulnerable groups
- Producer-oriented policy supporting farmers to increase their production.

In general, they move from food security-based strategy to a food self-sufficient based strategy.

In 2001 the UN proposed the Millennium Declaration to free the world from hunger, poverty and promote human dignity and equality. Afterwards, in 2015, the UN developed the Sustainable development goals, in which goal 2 aims to fight hunger (Zero hunger) achieving food security, improving nutrition, and promote sustainable agriculture by 2030. These goals are still on the table and shaping the ongoing intervention and their impact evaluation in developing countries.

The issues of food security have been an increasing source of concerns among both national and international bodies since WWII. In the first years after WWII, the main concern was addressed on food production at the national level, then on access and diet's appropriateness at the household level. The different economic approach had resulted in fluctuating developing programs which had not always ensured a constant economic and human development.

3.2. Household Food Security

As mentioned in the previous chapter, food security definitions have been derived from an evolution of targets (national level and then household, till individual focus) and approach. A good starting point to analyse the concept of FS is that Food Security is "nonmaterial, unobservable construct, for which no objective benchmark exists" (Cafiero et al. 2014). Therefore, describing the FS concept with a single definition has been quite hard, because of the evolution of the concept through the years, the different approach in the research fields (agriculture, economics, public policy, health, sociology, anthropology) to the national and international bodies that work on it. This richness of definitions brought to difficulties in identifying what is being discussed or measured upon (A. D. Jones et al. 2013).

Despite this, the broadest definition used is based on the definition proposed by the FAO in 1996 during the World Food Summit:

"*Food security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*" (FAO 1996).

The definitions evolved from the first version stated at the end of World War I:

- Since the end of World War I , States arranged food balance sheet to measure the total quantity of foodstuff converted in calories available for the population, both produced or imported; in this stage the focus is on the availability because the major problem was to ensure enough food to cover the needs of the population (FAO 1946, 1952, 1963);
- Food availability, even if it is a fundamental dimension of food security, it is not a sufficient condition for ensuring that households are in food security. As argued by A. Sen (1981), under the specific condition the entitlements of the household to get food may be lacking under high food prices and low incomes (even with sufficient food supply);

- So, in 1983, the concept of "access" was introduced in the definition, adding that "all people at all times have both physical and economic access to the basic food that they need" (FAO 1983);

- A further step was the shift from individual to household level focus. That happened because of the emergence of intrahousehold behaviour analysis. Information on behaviour showed how vital is the allocative intra-family decision, which affects the physical and economical distribution of food. This consideration introduced a "collective approach" instead of "unitary models" (Haddad et al. 1997) which led to the use of "household food security" expression;

- In the mid-1990, another vital issue came to the stage: the micronutrient undernutrition. This new awareness about micronutrient shifted the attention from a caloric point of view to the overall diet quality (Shaw 2007; Gibson 2016). That led to the introduction of the "utilisation" concept into the definition of food security, along with the importance of the appropriateness of food, meaning that the social and cultural aspects shape food preferences. These two considerations ended up in the adding to the definition of a "safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996);

- Finally, in 2001 the definition was refined in: "Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2002). This last definition of food security introduces the fourth component (very often ignored): the stability over time of the condition of food security, i.e. "at all times".

Therefore, the evolution of FS definition clearly stated that FS is composed of four dimensions, namely availability, access, utilisation, and stability.

- Availability is intended as the possibility to use food supplied through domestic production, import or storage (that include food aids, although they are not subject to market rules);

- Access is intended as the possibility to have entitlements for getting appropriate food. Entitlements are a set of all commodity bundles which give to a person the legal, political, economic and social arrangements ability to collect food (i.e., traditional rights such as access to shared resources);

- Utilisation is related to the possibility to a person to compose an adequate diet, use clean water, as healthcare to reach a state of well-being, meeting each physiological need.
- Stability is intended as the possibility to a person to have access to adequate food at all time, i.e., not suffering from an economic or climatic crisis or cyclical event.

Figure 3.1 shows the relation of the four component and the pathway that link the loci of food security.
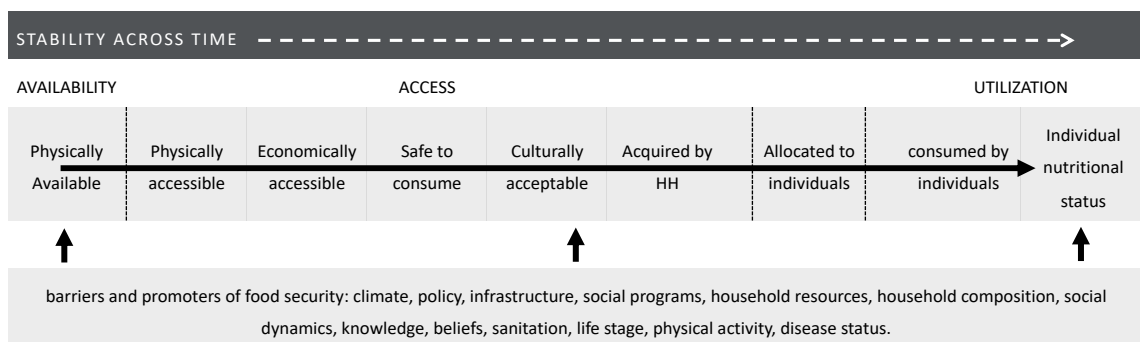
Figure 3.1 Food Security loci conceptual pathway and domain (modified by Jones et al. 2013)

The representation in figure 3.1 is a heuristic simplification, which illustrates the complexity of food security and the reason why defining and measuring it is not that simple.

Food Insecurity and Nutrition Security

Before introducing how to measure food security, it is worth to mention the fact that in literature, it is also possible to find the notion of Food Insecurity and Nutrition Security. According to the definition of FAO 1996, food insecurity is present when one or more conditions of food security are absent, namely when "limited or uncertain availability of nutritionally adequate and safe food" (FAO 2003). Alternatively, "[food insecurity is the] inability to obtain adequate food in quantity and quality because of lack of money or other resources" (Cafiero et al. 2014). Food insecurity can be transitory, when the condition of food insecurity relates to a relatively short period (economic collapse, natural disaster), or chronic, when it is associated with continuing or structural situations, such as structural poverty or low incomes. Meanwhile, undernourishment, which is the most severe situation of food insecurity, is defined as the "caloric intake below the minimum dietary energy requirement" (FAO, World Food Programme, and IFAD 2012) and undernutrition is defined as: "resulting from undernourishment, poor absorption and/or poor biological use of nutrients consumed"

(FAO, World Food Programme, and IFAD 2012). Another aspect which as to be taken into account when food insecurity is analysed is the malnutrition, which is defined as "an abnormal physiological condition caused by deficiencies, excesses or imbalances in energy, protein and/or other nutrients" (FAO, World Food Programme, and IFAD 2012. Sometimes, undernourishment and hunger are used interchangeably (A. D. Jones et al. 2013).

Nutrition Security is, compared with food security, a broader definition, that takes into account also healthcare and hygiene (because the illness is per se a cause of nutrient losses), together with food security. Thus, Nutrition Security is "*A situation that exists when secure access to an appropriately nutritious diet is coupled with a sanitary environment, adequate health services and care, in order to ensure a healthy and active life for all household members.*" (FAO, World Food Programme, and IFAD 2012).

After clarifying the meaning of Food Security and Food Insecurity and Nutrition Security, it is possible to introduce the metrics which can return a likely condition of people food security. This topic will be covered in the next section.

3.3. The measure of Food Security

In this section, we try to compendium the main FS indicator by category. Food security can be measured in each component (availability, access, utilisation, stability), or a combination of them. The analysis can be made from different sources of data (from an individual, to a national or regional level). The tools could be a simple indicator with a low labour-resource intensity to precise and detailed ones, which require time and resource-intensive data collection involving sophisticated statistical analysis. Regardless of these considerations, the validity of a measurement tool is inseparable from the purpose for which it is intended (A. D. Jones et al. 2013). The metrics used for food security measurement can be classified in several ways:

- The scale of estimation (national, regional, household or individual);
- Domain measured (physical availability or access, economic access, nutritional status, food quantity, food quality, food safety, individual nutritional status, anxiety, food preferences);
- Data sources (food balance sheets, food price data, global database household surveys, focus groups, and discussions);
- The concept of food security (food consumption adequacy or behavioural response) (Cafiero et al. 2014).

According to Jones et al. (2013), the metrics (or methods, or indexes) can be classified into six typologies, as shown in Table 3.2. The classification was made according to what the index measure, the purpose and the data source.

Table 3.2 Food Security Metrics classification

	Category		Food Security metric		
1	National-level estimates of food security	a	Prevalence of Undernourished (POU)		
		b	Global Hunger Index (GHI)		
		c	Global Food Security Index (GFSI)		
2	Global monitoring and early warning system	a	Famine Early Warning Systems Network (FEWS NET):		
		b	Integrated Food Security Phase Classification (IPC):		
		c	Comprehensive Food Security and Vulnerability Analyses (CFSVAs)		
3	Measuring household food access	a	Household consumption and expenditure surveys (HCEs):		
		b	Dietary diversity proxy	I	Food Consumption Score (FCS)
				ii	Household Dietary Diversity Score (HDDs)
4	Measures based on participatory adaptation	a	Coping Strategies Index (CSI)		
		b	Household economic approach (HEA)		
5	Direct, experience-based measures	a	United States Household Food Security Survey Module (HFSSM):		
		b	Household food insecurity access scale (HFIAS).		
		c	Latin American and Caribbean Household Food Security Scale. ELCSA		
		d	Food Insecurity Experience Scale (FIES)		
6	Measuring food utilisation	a	Anthropometry		

1. National-level estimates of food security

   a. Prevalence of Undernourished (PoU), which is the indicator of target one Millennium Development Goals. It is a core FS measure used by FAO. It is based on food availability data collected at the national level and concerning food produced or imported and categorised for use (i.e., export, fed livestock, seeds, non-food uses, losses). The strong assumption is that the "mean of the distribution of calorie consumption in the population equals the average dietary energy supply" (FAO, World Food Programme,

and IFAD 2012). However, this assumption is lacking reliability because of the uncertainty about the quality of the data: it is difficult to estimate the amount of production and losses, especially in developing countries. Therefore, this measure may be viewed as a touchstone for cross-national comparisons and monitoring changes in macro-level trends (A. D. Jones et al. 2013). For these reasons, FAO provides 26 additional indicators along with PoU which take into account food access and factors that determine the access to food;

b. Global Hunger Index (GHI): is published by IFPRI (till 2018), Welthungerhilfe and Concern Worldwide as a measure of "hunger" at the national level. It combines four equal weight indicators (von Grebmer et al. 2017). States are ranked on a 0-100 scale categorised in 5 classes. Since GHI also uses health and undernutrition information, its interpretation as a measure of food security is not straightforward. The four indicators form GHI scores are:

   i. UNDERNOURISHMENT (PUN): the share of the population that is under-nourished (that is, whose caloric intake is insufficient);

   ii. CHILD WASTING (CWA): the percentage of children under the age of five who are wasted (that is, who have low weight for their height, reflecting acute undernutrition);

   iii. CHILD STUNTING (CST): the share of children under the age of five who are stunted (that is, who have low height for their age, reflecting chronic undernutrition);

   iv. CHILD MORTALITY (CM): the mortality rate of children under the age of five (in part, a reflection of the fatal mix of inadequate nutrition and unhealthy environments).

The indicators included in the GHI formula reflect caloric deficiencies as well as the poor specific nutrient intake that leads to a high risk of illness, poor physical and cognitive development, and death.

GHI scores are calculated[15] using a three-step process: i) collecting available data for each country from various UN and other multilateral agencies, ii) each indicator

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[15] GHI calculation.

The current formula was introduced in 2015 and is a revision of the original one that was used to calculate GHI scores from 2006 to 2014

receives a standardised score on a 100- point scale, iii) standardised scores are aggregated to calculate GHI. The three children indicators receive equal weight. This calculation results in GHI scores on a 0 to a 100-point scale (table 3.3), where 0 is the best score, and 100 is the worst. In practice, neither of these extremes is reached.

Table 3.3 Global Hunger Index severity scale (modified from von Grebmer et al. 2017)

GHI Severity Scale

≤ 9.9	10 – 19.9	20.0 – 34.9	35.0 – 49.9	≥ 50.0
low	Moderate	serious	alarming	extremely alarming

c. Global Food Security Index (GFSI): is developed by the Economist Intelligence Unit and sponsored by DuPont (GFSI 2018). This index combines 30 indicators related to food security, affordably, availability, food quality, and safety. GFSI is calculated every three months, based on food price data and opinions from a panel of experts, who assign weights to the indicators. This approach implies consultative methods.

2. Global monitoring and early warning system.

 These measures are predictive and are used in areas under severe food insecurity risk.

 a. Famine Early Warning Systems Network (FEWS NET): it is an international network established by the USDA, which provides overlook on food security (acute and chronic) in 25 countries (FEWS NET 2018). Local teams analyse various indicator, both productive (i.e., rainfall, agricultural production), and social-economic, such as price, trade, local livelihood, shocks, and political stability. Since April 2011, FEWS NET

Step 2, standardisation: each of the four component indicators is given a standardised score based on thresholds set slightly above the highest country-level values observed worldwide for that indicator between 1988 and 2013. The threshold for undernourishment is 80, based on the observed maximum of 76.5 per cent; the threshold for child wasting is 30, based on the detected peak of 26.0 per cent; the threshold for child stunting is 70, based on the observed maximum of 68.2 per cent; and the threshold for child mortality is 35, based on the seen maximum of 32.6 per cent.

 $PUN/80x100 = stPUN$, $CWA/30x100\ 0\ stCWA$, $CST/70x100 = stCST$, $CM/35x100 = stCM$;
Step 3, aggregation:

$$(1/3\ stPUN) + (1/6\ stCWA) + (1/6\ stCST) + (1/3\ stCM) = GHI\ score$$

changed the classification system using the Integrated Food Security Phase Classification (IPC);

b. Integrated Food Security Phase Classification (IPC): it is a set of protocols to identify the severity and magnitude of food insecurity, compare outcomes and identify common strategies based on the classification to cope with food insecurity (IPC Global Partners 2008). The IPC relies on Demographic and Health Survey and Multiple Indicator Cluster Survey data, as well as consultations with government and nongovernmental organisation authorities and data from household budget surveys. The IPC approach is consultative because it relies on expert panel interpretation of evidence from different research fields and type of information (i.e., food consumption, nutrition, health, hazards, livelihood changes) trying to build a broad consensus among multi-sector expert;

c. Vulnerability analysis and mapping methodology. These kinds of analysis are run by the World Food Programme (WFP 2008). Among these analyses, the most important is the Comprehensive Food Security and Vulnerability Analyses (CFSVAs). This analysis uses information collected by baseline questionnaire given to families during no crises time. This analysis provides broad information from food supplies, nutrition, health, education, market, political, and socio-economic information, helping to draw up the first emergency response. WFP runs this analysis since 2003.

3. Measuring household food access

These kinds of surveys try to capture access to food at the household level. Food access can refer both to economic and/or physical access:

a. Household consumption and expenditure surveys (HCEs): FAO develops this measure making a combined questionnaire (household food consumption, expenditures, and living standard measurements). HCEs operate under the assumption that food purchased is equal to the food consumed. Thus, because of the possibility that food can be also be lost or wasted, given to an animal or as a gift, under or overestimations can happen. So, HCEs can measure poverty, consumer price index, family status, patterns on food and non-food consumption but is not suited for individual consumption, food losses and waste and food consumed out of the household analysis.

b. Dietary Diversity proxy: these measures collects information about food product groups consumed during a specific period at the individual or household level. This measure is

linked positively with the nutrient quality of the diet (Hatløy et al. 1998; Workicho et al. 2016). Several international bodies use this kind of approach in order to assess food security access.

i. Food Consumption Score (FCS): it is a measure elaborated by the World Food Programme (WFP 2008) which combines data on dietary diversity and food frequency using 7-days recall data from CFSVAs and emergency food security assessments. These pieces of information are easily collectable, and the index is easy to elaborate. The sheets collect frequency of consumption of each 12 groups of food: main staples, pulses, vegetables, fruit, meat and fish, milk, sugar, oil, condiments. Per each product group a panel of experts assigned a weight based on energy, protein and micronutrient density of each group: meat, fish, and milk = 4, pulses =3, main staples = 2, vegetable and fruits = 1, sugar and oil = 0.5, condiments = 0. FCS is positively correlated with kcal assumption per capita per day, asset indices, total monthly household expenditure both in Africa and Asia (Wiesmann et al. 2009). FCS has a cut-off point of 7 determining levels of severe food insecurity.

ii. Household Dietary Diversity Score (HDDs). This instrument is developed by the Food and Nutrition Technical Assistance (FANTA) Project -USAID (Swindale and Bilinsky 2006; FAO 2013). The score is calculated checking the presence/absence of 12 food groups in the diet, obtaining a score from 0 to 12. The same weight food groups are cereals, white tuber and roots, vegetables, fruits, meat, eggs, fish and other seafood legumes, nuts and seeds, milk and milk products, oils and fats, sweets, spices, condiments, and beverages. It is possible to elaborate an equivalent diet diversity score for an individual (DDSs) with 0 to 9 score, according to a different arrangement of food groups. Because HDDs is used in this research will be presented in detail in chapter 5 (Materials and methods) on page 67.

FCS and HDDs have lots in common but differ from the recall period, type, weighting, and the number of food groups and cut-off points, plus the frequency of consumption. Despite that, these two indexes can have roughly the same performance in measuring food security (Kennedy et al. 2018).

4. Measures based on participatory adaptation

These measures take into account the context where people are living, collecting specific information.

a. Coping Strategies Index (CSI): CSI is developed by CARE and WFP. The index collects information about how the household copes with food shortage, aggregating such information into a score. The answer to this question: "What do you do when you do not have enough food, and do not have enough money to buy food?" is a perfect example of the meaning of CSI (Maxwell et al. 2003). CSI presents a list of coping strategies covering one-month recall. Then, the second round of focus groups provides information on appropriate weightings related to the severity of food shortage. These weightings are then grouped, and scores are assigned to each group. Also, the frequency of cope strategies is assigned with a score. All this information are combined in the final index score. CSI is not meaningful by itself, but when it is compared with other families in the same area or within the same family over time, CSI serves as a comparative indicator of food security of the household (Maxwell et al. 2003). CSI is adapted in a short version, with only five coping strategies tested into the field, with good results (Maxwell et al. 2003).

b. Household Economic Approach (HEA): it is an analytical framework (and not metrics) developed by Save the Children and FAO in the early '90s. Even if it is not a direct measure of food security, a set of procedures for assessing livelihood vulnerabilities produce information that can be used as a metric for food security. HEA is based on an interview of a focus group in 8-12 villages. Each focus groups is defined according to livelihood zones, wealth breakdown, and analysis of livelihood strategies for each of the identified wealth groups (Holzmann et al. 2008). Also, key informants both at the local and at the regional level, are interviewed. Among different topics covered, the HEA collects information on the ability of the households to access food and income as well as to identify appropriate interventions to improve access in the face of specific shocks (Boudreau 2008). Because of its comprehensive approach, the HEA can inquiry some determinants of food security that are not usually analysed, such as the decline of social capital as a driver of food insecurity (A. D. Jones et al. 2013);

5. Direct, experience-based measures

Unlike the previous approach, these measures have used questionnaires focused on household behaviour and lived experience, attempting to measure food security directly.

a. United States Household Food Security Survey Module (HFSSM): it was developed by the US government in the '80s to assess the problem of food security in the Country (Bickel et al. 2000). The tool is an 18-question survey module (USDA 2012) that asks the family in 12-month recall: 1) anxiety about household food supplies; 2) perceptions that the quality or quantity of accessible food is not adequate; 3) reduced adult food intake; and 4) reduced food intake by children (Bickel et al. 2000). Families are classified according to the condition of food insecurity and behaviour (Coleman-Jensen et al. 2018). An adapted version of HFSSM was used in developing countries, showing an association between food security and total expenditures per capita (Coates et al. 2003), and income strata and dietary diversity (Pérez-Escamilla et al. 2004). Since across countries the ways families cope with food insecurity are different, with different patterns of response, it is not possible to indicate a reliable cut-off for defining food security among countries (Coates et al. 2006);

b. Household Food Insecurity Access Scale (HFIAS). This tool is derived from the previous HFSSM, adapted for low or middle-income countries. HFIAS is a set of 9 questions (Coates et al. 2007), recalling the previous month, incorporating the frequency of food insecurity experience (i.e., rarely, sometimes, often). Several studies showed a positive association with standard household food security proxy, even if in a particular situation, HFIAS could misclassify families (Maes et al. 2009; Becquey et al. 2010). That could happen because families can give a different interpretation to the questions. Since HFIAS relies on a subjective interpretation of food insecurity experiences, changing internal standards or values could result in changed perceptions of one's food security status and therefore an altered score on the HFIAS (A. D. Jones et al. 2013).

c. Latin American and Caribbean Household Food Security Scale. ELCSA – Escala Latinoamericana y del Caribe de Seguridad Alimentaria, it is a variant of HFSSM, and HFIAS validated for countries in Latin America. This scale was presented in 2010 (Ballard et al. 2013). This metric uses a 15-question survey (8 for adults plus 7 if children are present) with yes/no response. The questions focus on food insecurity experienced in the previous three months. The score is obtained assigning "1" to questions with an affirmative answer. Total score ranges from 0-8 (adult) or 0-15 (considering children). A household can be classified as food secure (score 0), mild household food insecurity (score 1-5), moderate household food insecurity (score 6-10), severe household food insecurity (score 11-15) (INDDEX Project 2018).

d. Food Insecurity Experience Scale (FIES), proposed by FAO with the Voices of Hungry Project (FAO 2016) is an 8-question survey about food access, referring to a personal experience of food insecurity with yes/no response. The survey covers the previous 1 to 12 months. The model can produce two outputs: the prevalence of severe food insecurity, and the prevalence of moderate or severe food insecurity (Cafiero, Viviani, and Nord 2018). This tool is developed as an integration of other measures (such as PoU) improving the comprehension among different sectoral perspectives, such as agriculture, social protection, health, and nutrition (FAO 2017).

The experience-based scale is an auspicious tool to measure a valid concept of food insecurity at the household and individual level, especially if they are coupled with other indicators of individual/household socio-economic condition or nutritional status (Cafiero et al. 2014);

6. Measuring food utilisation

a. Anthropometry: food utilisation focuses on the analysis of the distribution of food within the household, the nutritional quality of food, and the bioavailability of micronutrient through the diet. Anthropometry has traditionally been used as a proxy measure of food utilisation (A. D. Jones et al. 2013) and is commonly used as a golden standard measure of nutritional status. Simple measurements commonly used are height, recumbent length (for very young children), weight, mid-upper arm circumference, and measurements of skinfolds. These data, along with sex and age, allow creating an anthropometric index for undernutrition (chronic or acute) evaluation (WHO 2009). Because anthropometry is influenced by food intakes, but also hygiene, health status, sanitation and access to caregiving and health services, it can capture more than quantity and quality of food intakes. That could lead a misunderstand the real inadequate intake of food (UNICEF 1990).

3.4. Criteria to evaluate Food Security indicator

As mentioned above, the indicators can be classified into several categories. Regardless of the type of indicator, each one has to be evaluated. There is no room here for an extensive discussion and evaluation of every food security indicator presented before. However, it is crucial to introduce some discussion on the topic. According to Cafiero et al., the criteria for evaluation are validity and reliability (accuracy and precision) (Cafiero et al. 2014).

Validity has to be intended as the degree to which both evidence and theory support the interpretation of measure entailed by the use of the tool. To properly evaluate these criteria, it has to take into account also statistical aspects, which are often overlooked in the most discussion on food security (Cafiero et al. 2014). Validation can be made using a golden standard (which is hardly achievable) or through other measure made by another formula (assuming that a priori the concurrent measure is valid).

Moving to the reliability, a tool is defined as "reliable" when it produces good results, which means it has good accuracy (or trueness, so small systematic errors) and excellent precision (so small random error). There is no direct measure for accuracy. Therefore, it is necessary to measure indirect evidence on the attribute of interest through a theoretical model (Cafiero et al. 2014). Changes in attributes are linked to changes in the observable evidence. The problems of systematic error in measurement and invariance (i.e., the same object in different conditions can be measured with similar precision), are more challenging to solve. Feasibility is related to the possibility that sufficient, reliable, and valid measures can be obtained under standard conditions (Cafiero et al. 2014). However, even If a measure is feasible, it does not mean that it is all acceptable.

Particular attention has to be paid on multidimensional measures, namely indicators which aim to capture more than one dimension of food security (availability, access, utilisation, stability). The definition of what is being measured may confound with its measurement, to the point that using different measures would imply the adoption of different notions of the phenomenon being analysed (Cafiero et al. 2014). So far, it is hard to define a golden standard that allows a direct comparison among these indices. Understanding the phenomenon underlying FS, the related monitoring and communicating activities in the theoretical framework is fundamental. Namely, the cost-effectiveness and the time effort cannot be the only concerns in indices choice. At present, the best choice is to combine more indices that analyse different point of view on FS. For instance, it is possible to use HDDs and FCS to have a cot-effectiveness and timeliness tools and an experience-based scale to better understand the determinants and consequences of household and own food insecurity (Cafiero et al. 2014).

3.5. Summary

The purpose of this chapter has been to define the concept of food security, the evolution of FS meaning through the history and the tools used to make it measurable. Thus, the literature on these topics was reviewed. Food security arises as an issue after WW II, in a food scarcity-growing population situation. The focus moved from national production to household policy target along the latest 80 years. This shift re-centred the problem, not only giving importance to production but also on the other pillars of food security: availability, utilisation and stability. To measure these different aspects, the researcher proposed different indices to measure food security. It is possible to resort to a different measure, or index or proxy, according to the level of aggregation (national/regional vs household/individual), set of information collected and the dimension of food security (availability, access, utilisation, and stability). The chapter concludes with a short presentation of the criteria used for the evaluation of the index. Among the essential findings discussed in this chapter, we have that:

- The household is central for food security because the allocation of resources it is intimately linked to the characteristics of the household;

- Small farmers are the target of rural development projects because they are the first step for developing linkages with the non-rural sectors;

- Rural development is related to food production and other off-farm activities that can strengthen the whole rural economic ecosystem.

- It is possible to measure food security using different measures or indexes which are not entirely overlapping, due to the different scale, domain, data, and concept.

- Each measure has to be evaluated under two criteria: validity, reliability. Because there are not golden standards, it seems reasonable using more than one indices to give a more accurate picture of the situation.

4. The "Production of appropriate food: sufficient, safe and sustainable" project

In this chapter, the project "Production of appropriate food: sufficient, safe and sustainable" (C3S) will be presented. The Project Background (4.2) shows the global context in which the project has been inspired, namely the interest in feeding the planet (Expo 2015) and the promotion of rural development in developing countries. In 4.3 the theoretical model and ethics which shape and uphold the project will be discussed. Then, 4.4 subchapter presents the main project objective. From the general one, that is the promotion of Sustainable agricultural Intensification matching high productivity and genuine sustainability, to the specific long term target to the food supply chain through the women empowerment. Afterwards, in 4.5 the general project organisation in India and DRC, from the Diocesan Pilot Centre to the Parish Pilot Centre, will be presented. In particular, it will be provided with an accurate description of the Pilot Centre and the expertise requested to implement the activities. At the end of this chapter, the lines of action put in place to fulfil the project goals will be illustrated.

4.1. Project Background

2015 was the year of EXPO Milan, whose motto has been "Feeding the planet. Energy for Life". The Universal Exposition aimed to put into the light the perennial problem of feeding the planet between growing needs and limited resources. The whole food supply chain, through production, processing, and consumption until the giant themes of food losses and wastes, has been taking into the debate. From different voices rose the request for technological innovation and environmental protection in food production systems besides the consideration of human needs, which must always be guaranteed (Bertoni et al. 2016). That request has been insistent, particularly for Developing Countries. In this contest and preparation for EXPO 2015, in 2012 the Università Cattolica del Sacro Cuore, thanks to the generous financing of the Fondazione Romeo and Enrica Invernizzi, has promoted the starting of "Production of appropriate food: sufficient, safe and sustainable" project (C3S).

4.2. Ethics and theoretical model

The project, usually called with the acronym "C3S", lays the foundation deeply in the Catholic Social Teaching and the aims of the Faculty of Agriculture, Food and Environmental Science (FAFES) of Università Cattolica del Sacro Cuore. Since the foundation of the FAFES in January 1953, the founder Father Agostino Gemelli wanted to declare the faculty's objectives: i) to educate the leaders for Italy's agricultural development and ii) to fight hunger in developing countries (Bertoni et al. 2015). Thus, to fulfil the aim of Father Gemelli, the FAFES has promoted the start of the project.

The project has developed a proper approach, founded on the following essential three concepts: bottom-up, holistic, and scientific.

The bottom-up approach refers to subsidiarity and participation. The project aims to help the rural population to develop actions and strategies to improve the livelihood in the perspective of supporting people energising the personal initiative. That could be possible only by applying the subsidiarity and participation principles (LEONE XIII 1891; PIUS XI 1931). Subsidiarity is a principle according to which the superior decision level (as the State, Province or other bodies) should not intervene in any matters that can be handled by families or the community. Superior decision level must be at the service of the families or communities, acting only when the families or communities are unable or unwilling to fulfil their rights or duties related to its members. Participation is complimentary to subsidiarity. Participation principles are about the duty of each person. Namely, it means that each person is called to building up the society in which they belong, putting at the service of the community their skills, knowledge, and ability (United Nations 1986, 2007).

While participation and subsidiarity refer to the type of relationship among the actors involved in the project, holistic refers to the environment in which the intervention happens. Holistic means that the property of a system should be viewed as wholes, not just as a collection of parts. In other words, it means that the rural development problems involve solving at the same time (comprehensively) several problems. Very often, that implies to address at the same time helping population with low education and low scientific-technical skills, in an environment lacking in infrastructure (both economic and physical) and social-administrative organisation. Focusing to the small farmers household, which are the beneficiaries of the project, that means to organise an intervention that takes into account the whole food supply chain: productive problems (quality of seed, soil fertility), conservation and processing

problems (losses reduction), consumption (namely diet quality) or commercialisation. Nevertheless, holistic approach has to involve the person as a whole; according to Pope Paul VI "To be authentic [the development], must be well rounded; it must foster the development of each man and the whole man" (PAUL VI 1967).

The third concept that leads the approach is science. The scientific approach wants to point out how the initiatives should be implemented. Interventions proposed by the project have to be validated through research and field experimentation, according to the principles "to know to deliberate" and through "sustainable intensification (SI) recurring to proper technology." SI is defined as "a process, or system, where agricultural yields are increased without adverse environmental impact and avoiding the conversion of the additional non-agricultural land" (FAO 2011b; Pretty and Bharucha 2014). Under this light, the word "technology" is used here to define ways of improving rural livelihoods such as new crop varieties, improved livestock breeds, agro-technical strategies, new approaches to food preservation, storage and handling (Lemba, 2009). In the perspective of food security, technology has to be appropriate, namely promoting a profitable exchange between indigenous knowledge and scientific and technical knowledge. People seek to achieve control of technology as they integrate technology with their knowledge towards self-sufficiency (Lemba, 2009).

4.3. Objective

The project objectives are both general and specific.

General

The main objective is to involve the FAFES in Sustainable Agricultural Intensification in developing countries, matching higher productivity and genuine sustainability. At the same times to establish, within the FAFES, a team with specific skills on food supply chain (from production to utilisation) which are needed for facing the problems of global malnutrition, especially in the developing world. That leads to experimenting with a model of rural development in developing countries, based on local human resources supported by FAFES expert team.

Specific

Moving from general to a specific objective, the project estimates nutritional needs, food availability and food preference of local households, based on general criteria of the Mediterranean diet (composed by grains, vegetables, fruits, legumes, but also animal products and fish), as well as water sanitisation. The Mediterranean diet is considered a milestone for the improvement of local diet because it is acknowledged as appropriate and balanced in each nutrition aspects. The project had collected valid data on foodstuff production (when, where, quantity, quality), both from plant and animal raw materials to provide a reliable nutritional estimation.

Proceeding along the food supply chain, the project provided appropriate techniques to preserve food products to minimise losses and to ensure the health and hygiene safety for consumers in a perspective of environmental sustainability of agriculture and energy production.

Another important aspect linked to rural development and the improvement of household nutrition is the women empowerment (Malapit et al. 2015). The project promotes women involvement in agricultural work, as well as off-farm generating income activities. Empowered women can efficiently allocate their time for child feeding and caring, agricultural work, and household chores to improve household and child nutrition (Murendo et al. 2018).

Last but not least the project aims to develop appropriate procedures for the technical training and assistance of farmers, to enable them to maximise production efficiency while minimising the food hazards and the impact on the environment in a frame of economic sustainability.

Thus, the Pilot Centre organisation in both India and DR Congo was shaped to matching these principles, as illustrated in the below paragraphs.

4.4. Organisation

4.4.1. General organisation

As mentioned before, rural development of populations with low educational level and low technical-scientific skills, associated with lack of infrastructures and socio-administrative organisation, implies the simultaneous solution of a series of concrete problems that oppress the populations (namely holistic approach). Thus, the "C3S" project is organised in 2 levels, the Dioceses and Parishes. These two levels are linked to each other, as shown in figure 4.1. Above the Diocesan level, there is the International coordination, which is based in Italy, at the Università Cattolica del Sacro Cuore – Faculty of Agriculture, Food and Environmental Science in Piacenza.

Both Diocesan and Parish level are organised as Pilot Centre (PC). The Diocese PC acts as a reference. Therefore, it is the link between the "knowledge providers" (i.e. Universities or Research Centres) and the "collectors" bodies of population needs (the Parishes). The second level is the peripheral Parish PC. This level is linked to the Diocesan PC as well as connected to farms to point out local issues and to disseminate new proposals. The solution proposal for the identified problems (hygiene, nutrition, cultivation, animal breeding, conservation, organisation, etc.) must be performed (and developed) at the Parish level.

The Parish PC needs low technical levels compared with the Diocesan PC, and it is mainly aimed to transfer the know-how the "innovations" raised within the diocesan centre trials directly to farmers. Below - in four main points - the relationships between the different organisation levels and the rural population are illustrated [16].
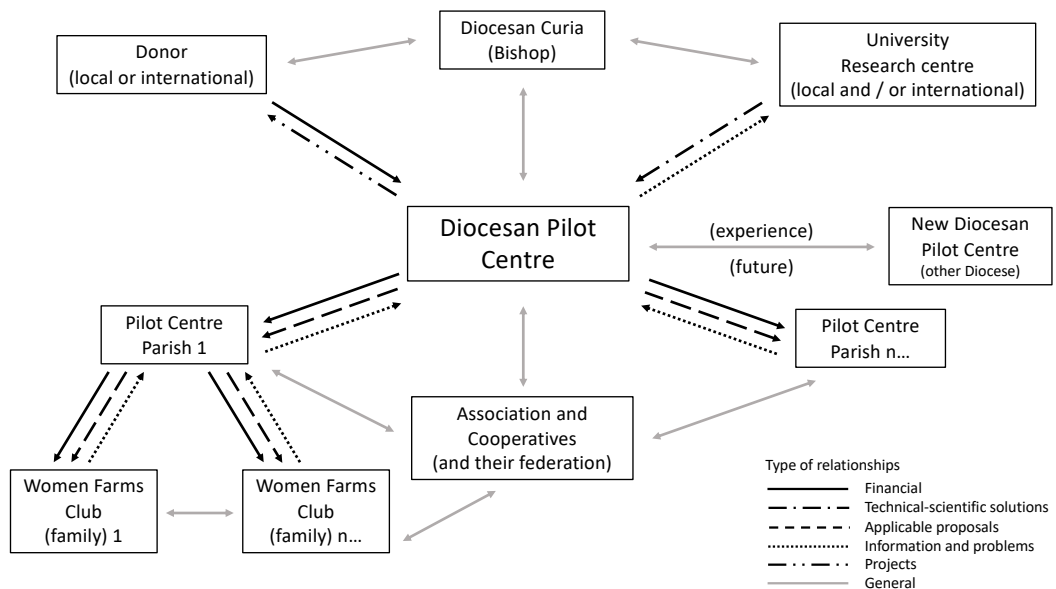
Figure 4.1 Relationship among levels, bodies, and subject in theC3S Project (modified by Bertoni et al. 2016).

Within the Dioceses of mission countries, the project establishes an office for agricultural development (Diocesan Pilot Centre) with just a few people that together have all the skills to face the needs of rural population development. This office should interact with the technical-scientific agencies (e.g., Catholic Universities and/or government research centres) and should organise and coordinate a certain number of Parish Pilot Centres (to be gradually extended to

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[16] Although, in the contest these relationships are referred to the Catholic Church structures, this is not exclusive but can be adapted for other bodies too, such as other churches NGO's.

all parishes). Therefore, some financial supports are needed to create a small technical team (at least 1-2 agriculture graduated) to cover the main intervention areas: plant cultivation and protection, animal breeding, food processing, and preservation, as well as nutrition education and organisation of farmer associations, etc. The financial support will be utilised for the team members training and to cover the costs of external technical support, but also to subsidise the small Parish PC, particularly in the early stage.

The Parish Pilot Centres, constituted by the Parish Priest with the support of *enterprising local farmers*[17] with a certain extent of training, follow the technical indications drawn-up by the Diocesan Centre to kick-start the development process within a restricted nucleus of parishioners (family farmer leaders). One of the first steps will be to establish groups or associations within which people can attend technical training in which to implement innovation. However, here, the most critical duty is to overcome harmful individualism by instilling a sense of sharing/community that shows participants the feasibility of the new ways in overcoming problematic situations. The financial support is going to diminish over time after a progressive self-liberation by the groups, but the technical support will remain to favour the spread of the initiative to all the parishes.

Caritas of donors' countries should financially support through local Caritas the PC in Developing Countries. At the same times, donors' Caritas should facilitate the transmission of knowledge to the local household through the PC. This exchange will allow limiting, as much as possible, the direct or continuous presence in situ of volunteers from western countries, which would have prohibitive costs. Moreover, they will facilitate the interaction between Diocesan PC (and Parish PC) and technical-scientific institutes (Universities or research centres within the country or in more developed countries). This interaction will enable the technical-scientific institutes to acquire knowledge and skills regarding local problems, and thus, they will be able to give suggestions on how to resolve them. These solutions can be applicable thanks to the assistance of technicians in the PC. The technical-scientific institutions will also produce training tools suited to the populations and will contribute to the continuous capacity building of pilot centre technicians.

The continuous education of the rural adult population will have a vital role for the PC (parish and indirectly diocesan that prepare teaching materials). Furthermore, it appears an excellent

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[17] Enterprising farmers are more capable small farmers, which are able to fill the knowledge and technologic gap acting as consultant for the others.

strategy to teach the principles (for implementing innovation and rural development) in the schools for missionaries and the seminaries, to have priests with some knowledge in that field. Teaching the basics of agriculture in the primary schools of the developing countries is also essential; as well as the professional training at secondary school (building, mechanics, electricity, woodwork, needlework, and agriculture) and facilitate the acquisition of the social-economic expertise needed for a steady development of the country.

4.4.2.Darenchigre, Meghalaya State, India

The Pilot Centre in Darenchigre was established in 2012, at the Sant'Alphonsa Parish, managed by the Missionary Congregation of the Blessed Sacrament Society (MCBS). The local team is composed by:

- Coordinator, which belongs to MCBS society and takes care of administrative issues, holds treasury and secretarial roles, as well as Project Representative on-site;
- Project Manager: expert in agricultural activities, it must organise works for the other team members, collect data, and write the internal reports.
- Nutrition expert, who had the task of monitoring the nutritional status of families surrounding the pilot centre;
- Plant production expert, which promote horticultural production, rice production, and orchard management;
- Animal production, which is in charge of poultry and eggs production, must follow the local farmers that are collaborating with the project, as well as cattle (both milk and work) and pig production;
- Mechanisation expert, which is in charge of tools and simple machinery, and related services to whom it may require it;
- Association coordinator, which take care of the men or women groups, which are involved in the project.

The local team has an office equipped whit scientific measurement tools (i.e., scales, rain gauges, metric tapes) elementary scientific library, technical sheet, computers, printer, and portable projector. Other buildings are utilised for tailoring school, a multipurpose room, warehouse and machines, and tools shelter. To fulfil the duties of demonstrations purpose, the PC has 7 hectares of land, of which four are under cultivation: paddy rice plot, terracing invested as the orchard, vegetable garden, plots for banana and pepper cultivation as well as

pineapple and mushroom farm. From the point of husbandry, PC build recoveries for chickens, cows, and pigs. The CP, along with bees, breeds all of this kind of animals. A multi-purpose vehicle, motorcycles and bicycles, motor-hoes and a threshing machine complete the PC's equipment. The centre is self-sufficient for electricity, thanks to a photovoltaic panel installed on the roof of the parish house. The Pilot Centre of Darenchigre is linked with several bodies:

- Dioceses of Tura, which Sant'Alphonsa Parrish belongs to;
- Block Developing Office (BDO) of Darenchigre, a State developing agency that provides service, information, technical advice on agricultural issues, such as plant production or animal production. According to the availability of input, block office can also provide tech input, such as organic fertiliser. Through the Farmer's Friend, which are capable small farmers (as the enterprising farmers that cooperate with PC at Parish level) who cooperate actively with de BDO, the small farmers are linked to agriculture knowledge and support network (Glendenning et al. 2010);
- Veterinarian Service, which provides health assistance (namely vaccination service), and animal welfare consulting;
- Krishi Vigyan Kendra Research Centre, which provides agricultural extension service, from animals to plant production. Among other activities, it is developing new rice management, other than improved rice variety;
- Women Farmers clubs, which are Self-Helping Groups that attend the project activities.

4.4.3.Kabinda, Lomami Province, Democratic Republic of Congo (DRC)

The PC in Kabinda was established in 2012 at Saint Pierre Parish, managed by a diocesan priest of the dioceses of Kabinda. The Parish is located in the city. Even so, a part of the parish encompasses the suburbs, where among the dwellers some field is cultivated. A few years later, the PC bought a significant piece of land, close to the river, where some facilities have been built. The local team is composed by:

- Coordinator, which is a priest and teacher at local University (University of Notre Dame de Lomami) takes care of administrative issues, holds treasury and secretarial roles, as well as Project Representative on-site;
- Two Nutrition experts, which have the task of monitoring the nutritional status of families surrounding the PC and promoting best practices in baby care and weaning;

- Animal production expert, which is in charge of poultry and eggs production, has to follow the local farmers that are collaborating with the project;

- Plant production expert, which promote efficient starchy production (corn and cassava), leguminous production, and orchard management;

- Mechanisation expert, which is in charge of tools and services required to whom it may require it;

- Two Association coordinators, which take care of the women and men groups that are involved in the project.

The local team has an office at the parish, equipped whit scientific measurement tools (i.e., scales, rain gauges, metric tapes) elementary scientific library, technical sheet, computers, and a printer. PC is equipped with vehicle, cycle, and motorcycle, as well as cultivator and chainsaw.

At the "Expo" site, which is at the end of suburbs of Kabinda, roughly 20 minutes on foot from the parish, the C3S Project has built two concrete chicken coops, a warehouse for poultry breeding, a warehouse for mill and concentrate feed mixer besides grain storage, guardian's house, and a building destined for Emporium. In this last building, one room will be equipped with a solar power station, a fridge (to keep cold vaccines), deep fridge, and hatchery (for chicks). To fulfil the duties, the PC has several hectares invested for the cultivation of corn, groundnuts, nièbè (which is a type of V*igna,* also known as cowpeas), manioc, as well as palm oil, coffee and fruits trees. Another piece of land is established at the villages of Kileta and Kitenghie as demonstration fields. Regarding the husbandry, the PC bred chickens for both meat and eggs production, as well as ducks and turkeys to the household. The PC is linked with several bodies:

- Dioceses of Kabinda, which Saint Pierre Parish belongs to;

- Radio Kabinda, which host a radio broadcast presented by the PC's team;

- University of Notre Dame de Lomami. The project hosts some student for the curricular stage. Meanwhile, the university let the project use pieces of land close to the new seat of the Faculty of Agriculture.

- Institute National pour L'Etude et la Recherché Agronomiques (INERA): it is a national research institute that provides necessary research of agricultural field to improve the food production in the DRC. Along with the University of Kinshasa, INERA provides plant and knowledge to support the activity in Kabinda through the PC.

- CEPROSEM: ("CEPROSEM") it is an NGO's based in Kinshasa, founded by *Opus Dei*, which are involved in horticulture seed production since 2005. PC and CEPROSEM signed a collaboration agreement. CEPROSEM provides quality vegetable seed, adapted for Congolese environment; meanwhile, PC is the official dealer in Kabinda and provide research service for CEPROSEM.

4.5. Lines of action

The lines of action are focused on the needs expose by the local team and the research team during the mission in loco. There is some similitude between the lines of intervention in India and DRC. However, as mentioned before, the two contexts are quite diverse. While in India the project operates in a rural area, in DRC we are operating in a border area around the city: the suburbs.

4.5.1.Darenchigre, Meghalaya State, India

In this section will be presented the line of actions adopted in India. The line of actions will be illustrated starting from the productive aspects (both animal and plant production), to the storing and preserving food, then the management of water, to conclude with the social and economic aspects.

Empowerment of livestock activities

With the aims to improve animal production, a survey has been done to identify the prior problem to face, and subsequently, some improvement actions have been taken. The bred species encountered in India are cattle, poultry, swine, goats, and fish. Usually, each family has a cow and two oxen. From the beginning of the project, it appeared that cow milk for consumption is produced with an average of 151.3 ± 84.9 kg by lactation. Two-thirds of the milk is consumed as milk tea (even for children) and one-third is sold (Bertoni et al. 2015).

As regard cattle, project actions focused on the proper management of cross-breeding local breed and Frisian. The first result seemed encouraging. In facts, that managing allows reaching 5-6 l/day vs the local production, which is 1 l/day (Ndereyimana et al. 2018).

Referring to poultry, an improved Indian breed (Kuroiler) good yielder of meat and eggs (fits under the same hygienic and feeding conditions of traditional breeds), enables the production of eggs of about 20 /head/month for several months and an average live weight of 3.5 kg/head which is more than double comparing the local breeds.

Also, swine bred were targeted. About that, improved swine breeds have been introduced. In the same conditions of management, the improved breed has 60 kg of live weight vs 40 kg of the local breed. The best management of piggery, emphasising better nutrition, has been promoted. Also, improved beekeeping has been encouraged.

The last livestock activity is referred to as fishing activities. The Pilot Centre set up a pond for fisheries, to provide information on ameliorating management of fish. It is an ideal complementary production, due to the nature of the land and the widespread presence of flooded paddy rice in the Darenchigre area.

Sustainable intensification in food crop production

The main activities were carried out on rice cultivation, fruits, and vegetables. The adoption of improved rice cultivation technique (System of Rice intensification-SRI) allowed savings about 50-80% of the seed at the sowing. Indeed, the use of improved varieties of rice has allowed an increase in the yield of paddy rice from 2-2.5 to 3.5 to 4.5 Mg/ha. An important issue is related to the availability of fertilisers. As mentioned in chapter 2, the Meghalaya State promotes Organic Farming practices. Thus, the PC encourage homemade vermicomposting techniques as well as the collection of dung to produce manure. Fruits and vegetable techniques were improved from nursery until their processing in jams and chips. Another introduced technique has been the terracing on sloping ground to increase the ability to cultivate such land without or reduced risk of erosion during the rains, which sometimes are torrential. The results showed the usefulness of the technique, both for horticultural and fruit plants; from cash crops, PC promotes the production of pepper production, planting this plant in woods and areca nut orchard. Along with pepper production, homemade mushrooms cultivation for own consumption and selling was developed.

Conservation

During cereals and pulses, conservation losses are significant. Thus, two approaches were set up. The first is based on the chemical treatment of warehouse with active organic principles (Azadirachtin); the second one utilises multilayer bags, which create an anaerobic environment inside the bags and at the same times inhibit the smell's spread out the bags. This second approach prevents both insect and rodent damages.

Household food processing and preservation

Homemade cassava chips (with salt or sugar) and potato chips have been introduced. Products are appreciated and have also been sold in two food exhibitions in Tikrikilla during the days dedicated to Expo 2015. The activity is upgradeable thanks to the allocation of home vacuum packaging machine provided by the project and the easy access to the oil for frying. Other trials are related to vegetable grilling, finalised to preserve micronutrient after a superficial grilling (nowadays is on research level).

Household water sanitation and hygiene

According to the results of our survey, 99 % of the targeted population consumed water from open wells. The introduction, as a trial, of household water filters, accompanied by hygiene education allowed a near-total disappearance of diarrhoea and abdominal pain, which dropped respectively from 51% and from 47% to only 1% in families that used them (in six months). This practice can be easily implemented in other families after adequate dissemination and education, especially for the use and maintenance of these filters, which are manufactured in India (Ndereyimana et al. 2015). Nevertheless, nowadays the Centre is promoting a slow sand filter, which has the advantage to be built at home, due to the basic knowledge needed, and with affordable costs.

Creation of income-generating activities and cash management

Two main income-generating activities (IGA) were introduced: weaving-tailoring and processed food commercialisation (mainly chips). The Darenchigre PC established a sewing workshop and production of various articles of the sector. Another activity is the bakery, in which the community can produce cookies and bread to sell or for their consumption. The third IGA is the rosary production, which uses local wood or plastic, is also put in place. Self Help women groups followed by an expert for both productive activities and income management run this two IGA. The income is managed through an individual bank account in a Microfinance Institution. Credit and saving management is also implemented. Commercial activities within the PC are mainly facilitated by the access to means of transportation to the purchasing of agricultural inputs (i.e., seeds, seedling) and other supplies used by the cooperative groups, but also the sale of products in more remunerative markets, thus with more financial value addition. A fourth IGA is the selling of chicks vaccinated to the local farmers. This service is quite valued among farmers.

Investing in building an active rural organisation with a skilled local team

One of the challenges faced by the C3S project is to overcome widespread individualism, through the structuring of the rural area of the PC with the organisation of self-help groups of women to resolve the common problems together. This required recruitment and training of a local team, although it is difficult to maintain it stable in the PC in a very changing labour market in the area.

Awareness program and social event

PC promotes training meetings on several subjects (medical care, agricultural production, food consumption). The focus is on building up knowledge and technical skills among the farmers. These programs can be at the PC or the village level, according to the particular needs identified by the PC staff.

Moving to Social events, they build up an active community is another target of PC activity. The promotion of some events, such as *women sports days,* has the goal of improving the relationship among beneficiaries. In sports games, women challenge each other in a sports game, such as tug of war, run, and other ability games.

4.5.2. Kabinda, Lomami Province, Democratic Republic of Congo (DRC)

In this section will be presented the line of actions adopted in DRC. As for India, the line of actions will be illustrated starting from the productive aspects (both animal and plant production), to the storing and preserving food, then the management of water, to conclude with the social and economic aspects. Of particular importance was the intervention on nutrition, particularly for children and adults.

Animal husbandry

The line of action has been focused on poultry. The PC has roughly 205 laying hens with an average daily production of 70%. This production of eggs allows greater access by households of the area who buy them willingly. The PC also distributes various poultry species (ducks, turkeys, and laying hens) that are enhancing access to animal protein especially for the involved families;

Plant production

Plant production is essential in that area. The action focused on three main topics: cassava cultivation, horticulture, and orchard. For cassava, a comparative test of 5 ecotypes of cassava

has identified the two best ecotypes (Ngoymuamba and Kakuanga) with a yield of more than 20 Mg ha (primarily if grown on the surface ridges), compared with the average of 5.4 Mg per ha declared by the farmers during the initial survey in the same area. Horticultural actions aim to introduce various vegetables (tomato, eggplant, onions, sweet potatoes, particularly the orange flash one to supply vitamin A), to diversify the diet and create a possible income source. Moving to the orchard, the team are spreading seedlings of moringa, acacia, palm oil, avocado, and mango and coffee. These trees have been planted to establish in the area surrounding the PC (but also the family's huts) an orchard to provide palm nut (oil production) and fruits both for fresh or jam use.

Storage

Locally produced metallic silos for storing grain (corn) can preserve perfectly for six months the kernel while a loss of more than 30%, as usual for the attacks of insects. Activities upgradeable thanks also to the use of the instruments (provided by the project) control for an adequate drying before storage. For the same reason, ongoing research against insects and rodents is based on the comparison between an improved quality of multilayer plastic bags and the local jute or monolayer plastic bags.

Improving nutrition

Problems related to nutrition are spread in this area (Fiorani et al. 2015). Therefore, a project developed appropriate measures for children and adult.

For children has been developing a mixture called "Santè", meals mainly supply proteins and fats with local ingredients (corn, peanuts, and soybeans) complementary to breast milk after three months. The children who have used it (even irregularly) grew by about 1.6 kg from 3 to six months compared to 1.2 kg of those who have not received it, and at the same time, it was registered an essential reduction of health problems.

Moving to the adults, we propose an improved version of fufu, a typical starch source dish, recipe together with peanuts, characterised by a higher content of protein and lipids, but also appreciated by local people. Other exciting trials is related to vegetable grilling, finalised to preserve micronutrient after a superficial grilling (nowadays is on research level). Vegetables are cut in quite thin slices and then put in a grill for a few minutes per side. Thus, on the surface were sanitised meanwhile in the internal part (which is not contaminated) the heat-sensitive micronutrient is preserved due to the short exposure to the heat.

Water filtration

PC promotes a sanitisation of water through several technologies: solarisation, which implies the use of plastic PET or glass bottles let under the sunlight for 5 or 6 hours, and a slow sand filter, which takes advantage of predator behaviour of microorganism in different layers of sand. Both the techniques are in a testing phase;

Farmer's organisation

To overcome the typical individualism, the PC improves the organisation of self-help groups (GAM -*Group d'Assistence Mutuelle*) to resolve together with the common problems. Access to means of transportation, to the acquisition of agricultural inputs (i.e., seeds and seedling) and other supplies used by the self-help groups, but also the sale of surplus production toward more lucrative markets. Among the activity, we mention jam production. That production is justified by the exploitation of a large number of fresh fruits that is not possible to store (the refrigerator line is not available). Another production implemented is the peanuts oil, because of the critical value on the market. Last but not least the radio broadcasting at Radio Kabinda: this broadcast has the aims to spread information on ameliorating agricultural practices and tips for hygiene and childcare.

4.6. Summary

In this chapter, the project C3S has been described, from the organisation to the lines of action proposed both in India and DR Congo.

This project began in 2012 designed a model with a multi-sectoral approach of innovation and knowledge transfer to overcome subsistence agriculture (acknowledged for promoting hunger and malnutrition) and rural poverty in developing countries, through the implementation of a sustainable agro-system-management. The project approach can be summarised in three words: bottom-up, holistic, and scientific. C3S has put in place several linkages through either the different levels (from Parish to Diocese, until the expert team in Italy), among different actors in loco (dioceses, people groups, research and university bodies) with the aims to *do with* the small farmers, instead to *do for* them.

5. Research design, data collection and methods

The purpose of this research was to provide an evaluation of food security of the "C3S" project. This chapter describes the research setting, data collection and methods adopted to assess the research reliability. It has two sections: Research Settings and Target (5.1), and Methodology (5.2). The Research Settings and Target Section provides information on both India and DR Congo, where the research has been done, and the targets of the surveys for households. The Methodology Section presents the questionnaires, the preparatory activities and the sampling procedures. Furthermore, it also presents a more in-depth discussion of the HDDs index and finally, the statistical approach.

5.1. Research settings and target

Settings – Darenchigre

The project run in the area of West Garo Hills (WGH), one of the districts of Meghalaya states. Meghalaya is one of State in the North – East region of India. Garos, the tribe that has given the name to the district, are descendants of Tibeto-Burmese (Sinha 2010) and belong to the Bodo family. The Garos settled in different regions of NE of India and Bangladesh. Then, they moved from a different direction into Garo Hills and settled down in small villages. Garos are a clan society and follow a matrilineal society (Sinha 2010). That means that the youngest daughter inherits the house and the land with the obligation to care for parents during oldness. It is customary for the husband to move to the home of his wife after marriage. Initially, the known clans were Sangma, Marak and Momin. Later clans like Areng and Shira and others arise (Nipuni Mao 2011). Garos are Christians, in majority Catholic.

The Pilot Centre is located at Darenchigre, at Sant'Alphonsa parish (25°56'27.5"N 90°17'25.2"E), administrated by Missionary Congregation of the Blessed Sacrament Society (MCBS). Tikrikilla is the closer important town to Darenchigre, and headquarters of the main government agencies operating in the district. For the infrastructures, the road (SH 2) linking Darenchigre to Tikrikilla and the road connecting Lakhimpur to Guwahati (Assam State), (SH 12), which is the primary communication route in the area, are under reconstruction. The nearest markets are those of Tikrikilla, Lakhimpur (Assam) and the small market of Lambupara. There are two schools in the village: the state schools and the MCBS's fathers one: kindergarten, primary and secondary (under construction).

The population of Darenchigre is predominantly employed in agriculture and, as indicated by local authorities, in conditions of poverty and backwardness higher than the other inhabitants of the district of Tikrikilla.

Garo hills are in a humid subtropical climate, which is warm and humid except in winter, that tend to be foggy. The area is under jhum agriculture (typical slash and burn techniques), except paddy cultivation which is long monoculture. The main staple crop is paddy (planted in July – August and harvested in November – December) in the low flat land. Small plots in the hills are invested in orchards, such as pepper, coffee, betel nut and banana. Livestock is also present as cattle (smallholder zebu), goat, pigs, poultry and pond for fish.

Settings – Kabinda

The Pilot Centre is located at Kabinda, which is the chief town of Lomami province (6°08'20.8"S 24°30'42.9"E). In 2004 it had 126,723 inhabitants. The city rises on a series of hills and is connected to Mbujy Mayi and Rwanda by the National Road 2, which has been in poor condition from several years. Communications are therefore tricky, especially during the rainy season.

The project collaborates with the Diocese of Kabinda, and the Pilot Centre is at the parish of Saint Pierre (6 ° 08'30.3 "S 24 ° 29'35.8" E). The area in which we operate is peri-urban. The population has access to different markets in the city (the closest is in front of the parish of Saint Pierre, but not everiday, while the primary market is less than 1 km in the central part of the town). The population is predominantly Catholic, with small Muslim communities settling in the city.

The region falls within the Tropical Savana Climate and is characterised with four months of the dry season (from mid-May to August) coupled with eight months of the rainy season, sometimes interrupted by a short dry season in January/February. Thus, there are two distinct growing seasons, one from January to mid-May and a second from August to November (USAID 2016b). Daily temperature averages 25 °C and annual rainfall is close to 1500 mm. Typically, soils consist of a collection of sand on clay sediment (Muyayabantu, Nkongolo, and Kadiata 2013). Hills characterise the area. The most important crops are cassava, corn, groundnuts, plantain, banana, mango, papaya, coffee. Livestock is also present mostly as goat and poultry. Due to the presence of rivers, fish is available.

Description of participants

Target households of the surveys were both beneficiaries and non-beneficiaries of the "Production of appropriate food: safe, sufficient and sustainable" project. Households were considered a unit of analysis because they are the target of interventions. A household can be defined as one person or a group of people, related or not related, which live in the same house, sharing living space, at least one meals per day, some resources and economies of scales (Shaner, Philipp, and Schemehl 1982; Smeeding and Weinberg 2001). The head of the house is definable as the person responsible for governing a group of people that live in the same dwelling. Since household decisions affect individual food security (production of foodstuff, distribution of food, the general income of the household), this research is focused on rural household both in India and the Democratic Republic of Congo.

The source of information (respondent) in the household was the head of the household (or his/her partner).

For the sample of beneficiaries, the households were selected randomly by a member of the local team, who compiled a list based on memory. When a selected household was not available, another one was randomly chosen. For the non-beneficiaries, it was not possible to obtain a complete list of the household that lives in the surrounding area. However, because of the socio-economic contest, the local team was able to target random families who live in the same conditions as the beneficiaries. The non-beneficiaries families were selected according to few fundamental characteristics: the families have to live in the same areas where are living the beneficiaries, the family should belong to Garo tribe (in India), practice some form of agriculture (namely cash crops, paddy production, animal husbandry) and receive no goods or services from the PC. This few characteristics are considered sufficient to define a control group, due to the common economic environment in the surrounding area.

It was planned to interview roughly 200 families both in India and DRC. The sample number was determined on the economic and temporal availability base of the project. The design project envisages that the beneficiaries are followed over time in terms of technical assistance as well as means of production. This implies some beneficiaries suited to the overall availability of the Pilot Center. The original choice was to make a small group that serves as a "positive example easy to copy for neighbours".That has resulted in a compromise between the best amount of the family involved in the survey and the time local staff has been spent in the interview While in India the target was almost reached, in DRC, the situation has revelled more complicated than expected. That led to interview less than half of the families targeted.

However, in both cases, the local staff has been able to interview both beneficiary and non-beneficiary families. The total sample consisted of 194 households for India (sorted in 112 non-beneficiaries – NB - family and 82 Beneficiaries - B) and 83 for DR Congo, sorted in 45 non-beneficiaries (NB) family and 38 Beneficiaries (B).

The sampling error that may have been introduced by this selection procedure was considered insignificant because the socio-economic conditions are homogeneous among households. Nevertheless, the presence of selection bias was reduced using a proper statistical approach, the propensity score matching, which will be described in the following sections. Along with the questionnaire, a target interview with key persons (physicians, rural head office, local traders) was conducted. Other sources of information were the internal report of the PC and Mission Report of the Italian team.

5.2. Methodology

5.2.1. The questionnaire

The survey questionnaire used in this project derived from the World Bank – Living Standard Measurement Study questionnaire, which is conducted since 1980, and Living Standard Measurement Study - Living Integrated Surveys on Agriculture (LSMS-ISA) (World Bank 2018), adapted in accordance to the aims of the project. The questionnaire is composed of two parts, general and agricultural, and is divided into 18 sections:

- Household member list: lists age, sex, relationship with the head of household, and primary occupation of the previous 12 months for each member of the family;
- Education: the highest level of education reached by each member of the family;
- Health: enquires what kind of disease each member of the family has suffered from in the previous month, focusing on diarrhoea and children's nutrition;
- Labour: type of occupation;
- Credit, housing and water sanitation: this includes the two most important sources of income (type and amount), credit access (if the family borrowed cash, goods or services, how they used the loan, who disbursed the loan); and which are the primary sources of water and which measures the family takes to sanitise the water;
- Assistance and groups: if the family has been involved in a project, scheme or initiative promoted by the government, NGO's or other bodies that disbursed cash, goods or service, namely rural grant or cash for work activity;

- Recent shocks to household welfare: over the past years which have been the up to three events that affected the household negatively;

- Food consumption away from home: how many times each member of the family eats outside the household, average expenditures, type of meal and where they get food;

- Food consumption over the past week: per each food, it asks if the family (as a whole) the food consumed, the quantity and the source of food (own production, market, gift);

- Household member roster: this section asks the number of plots cultivated if the family has used or received organic or inorganic fertiliser, pesticide, inputs on credit, and if the cultivation is intercropped or not;

- Crop by the plot: this section is focused on paddy (India) or corn, manioc, groundnuts or niebè (RD Congo). Seeds and sowing losses: the amount of area sown, seed per m^2, seed origin and type; Harvest and harvest losses: area harvested, the reason for losses;

- Storage and post-harvest losses: the amount of product stored, storage methods, type of protection, the reason for losses; quantity sold;

- Permanent crops: type of crops, production, type of losses, storage methods, the reason for losses, quantity sold;

- Processed agricultural product: if the family has processed any products in the previous year;

- Livestock: concerning the previous year, it asks the number and type of animals, how many heads have been sold, slaughtered, lost;

- Any another husbandry productions: the amount of milk, eggs or honey that has been produced and eventually sold;

- Fishery and aquaculture: methods of fishing, amount of fish sold or processed and then sold in the previous 12 months;

- Extension: if the family has received some goods or services from the government, large farmers, bodies, or from the project.

The questionnaire was not explicitly designed for collecting information on food security or for impact analysis. Only a few sections were used to run the statistical analysis. That is because the project needs to collect information for the other research group involved in it. That extended questionnaire version prolonged the interview timing resulting in greater

difficulty in collecting data, leaving no room for other questions on the food security subject. However, the information collected could be used for impact analysis, especially those gathered on household food consumption and animal husbandry. Meanwhile, the other information gives the general ideas on the situation, from various points of view, namely social, productive, food consumption and economic. This mass of information allowed us to understand better the reality in which the project operates.

Activities undertaken before beginning data collection

According to the "guidelines for measuring household and individual dietary diversity" (FAO 2013), the questionnaire was adapted to the local survey context in cooperation with the local team. First of all, the questionnaire was translated by the local staff in Garo language in India and French in DRC. The team provided information on the local names for foods, clarification on habits of the population and the appropriate local words to reflect a consistent meaning. The translated questionnaire was reviewed with the local team to verify the adherence of the questions to the aims of the project and the comprehensibility of the questions. The questionnaire translated was printed, along with a guide, which contains a list of questions and general indications on how to collect the information. The last step has been the training of enumerators through classroom instruction, discussions and field practices which allow the interviewer to familiarise himself with the questionnaire. After the first sampling day, the enumerators had a briefing session with members of the research team to answer questions which arose during the interview. During the first week (both in India and in DR Congo) the supervisors checked the quality of data collections.

5.2.2. Sampling procedures

The local teams, once the preparatory and training activities were complete, the teams of PC started the survey. As mentioned before, this activity has been complicated because where we are operating, there are no agencies specialised in administering questionnaires, as well as by the time and financial constraints. Thus, the project did rely only on people from a local team, which are not professional enumerators. Even if this can introduce sampling and response errors, it was the only way to get the information on households involved or not in the project. The interviews were conducted by five enumerators in India and six enumerators in DRC which, however, constitutes an advantage because they are familiar with the project,

people and the socio-economic environment. Along with households, both India's and RDC's information is completed by direct interviews with the key informant.

5.2.3. Statistical Analysis

The Matching

The goal of this research is to analyse the difference between households' outcomes with or without the treatment, that is attending the activity of the PC. It is commonly recognised that it is not advisable to take the means of non-beneficiaries as an approximation, because usually even without treatment there are some selection bias and the real difference between the treated and control groups do not represent the real impact of the project. The basic idea is to select a certain number of households in the control group which are similar to those in the treated group for some pre-treatment variables. Thus, the difference in outcomes between beneficiaries and non-beneficiaries can be attributed to the intervention.

The parameter which we are interested in is the ATT (average treatment effect on the treated), which is the effect on those who are involved in the project and is defined as the difference between expected outcome values with and without treatments for those who participate the intervention (Caliendo and Kopeing 2008).

Because of the nature of the intervention analysed in this research, it was not possible to make a perfect random sampling among beneficiaries and non-beneficiaries. This condition does not allow to use as counterfactual the non-beneficiary outcomes. That is because the component which determines the participation in the project decision can also determine the outcomes variables of interest (Caliendo and Kopeing 2008). Among others, some sources of bias could be:

- participation might be endogenous as well as correlated with the outcomes of interest (more educated head of household, or younger, or "highly" productive farmers may have more propensity to participate);
- there might be some unobservable variables which influence both participation and outcome.

Matching is based on the assumption that sample selection bias can be eliminated by conditioning on observable variables, and it does so by matching each adopting household with one or more non-adopting households with similar observable characteristics.

Recently, matching techniques have been widely used in several impact studies of rural development and agricultural technology. Shehu and Sidiqye analyse the impact of non-farm

enterprise activities on household well-being (2014). Gitonga et al. (2013) studied the impact of metal silos adoption on households' maize storage in South Africa. Brunie et al. (2014) assess the impact of village savings and loans on household and children nutritional outcomes in Mozambique. Shiferaw et al. (2014) evaluate the impact of the adoption of improved wheat varieties on food security using a nationally-representative dataset of over 2000 farm households in Ethiopia. Zeweld et al. (2015) investigate the impact of small-scale irrigation on households' livelihood in Ethiopia. El-Shater et al. (2016) study the biophysical benefits of zero tillage in the context of small and medium-scale farmers in Syria.

This study uses Score Matching to evaluate the impact of the project C3S on food availability and food access. Two parameters are frequently estimated in literature: the ATT (1), namely the average treatment effect on the treated (causal effect), would be the difference in the outcomes between the two status (beneficiaries; not beneficiaries).

$$\tau ATE = E(\tau) = E[Y(1) - Y(0)] \tag{1}$$

The second is the average treatment effect, ATE (2), which is the simple difference between the expected outcomes after participation and nonparticipation. Moreover, respond to the question: What is the expected effect on the outcome if individuals in the population were randomly assigned to treatment (Caliendo and Kopeing 2008)?

$$\tau ATT = E(\tau | D = 1) = E[Y(1) | D = 1] - E[Y(0) | D = 1] \tag{2}$$

In both cases, each household can assume only two statuses: beneficiaries or non-beneficiaries.

The Matching Technique

In order to implement the matching, two aspects have to be considered, namely the variable selection and the fulfillment of SUTVA (Sustainable Unit Treatment Value Assumption). The variables will be presented in the next two chapters because there are differences between India and DRC. The variable choice has been made through bibliographic research, comparing different papers and by selecting those which are considered suitable for the analysis. Variables have to match several criteria: i) they must influence the participation decision and the outcomes simultaneously; ii) they must not be affected by participation; iii) they must

come from the same source (i.e. same questionnaire). Variables are then tested to evaluate those who are most important to keep in the models through their statistical significance. To achieve this, we proceeded with a full specification model then test up by iteratively subtracting set of variables to the specification, through a Likelihood-ratio test. The new model is kept if it is statistically significant and the prediction rates improve (Heckman et al. 1998).

Moving to SUTVA, it has two implications, namely consistency and non-interference. Consistency is referred to the treatment studied, namely the treatment has to be clearly defined in order to select correctly who is treated and who is not. Households can be classified only in two categories: involved or not involved in the project. Families are considered involved in the project if at least one member of the families attended training courses, is a member of a farmer group (men or women farmers' club) or bought some inputs or attend some training regularly from the Pilot Centre;

The non-interference assumption assumes that there is not passing information among treated and control or, in other words, that the treatment has non-effect in the outcomes of the control subjects.

As regards the matching technique, the most common method is based on Mahalanobis distance (Cochran and Rubin 1973), that is a measure of the distance between one point and one distribution. The distance is the number of standard deviations from the point to the distribution. Another common method for matching is the propensity score. According to this idea, Rosenbaum and Rubin (1983) suggest using a balancing score b(X), namely a function of the relevant covariates X such that the conditional distribution of X given b(X) is independent of assignment into treatment (Caliendo and Kopeing 2008) creating the PSM. Propensity score matching (PSM) is one of balancing scores that is based on the probability of participation in an intervention given observed characteristics X; such probability is estimated with a binary regression model (logit or probit). PSM works as an ex-post tool.

Another option considered in this research is the GenMatch (Sekhon 2011) algorithm due to the advantage that it could provide in this analysis. First of all, it can directly optimise covariate balances (Diamond and Sekhon 2013) as well as obtaining a better level of balancing without specifying the propensity score (Diamond and Sekhon 2013). GenMatch algorithm can work as a model and estimator as well as only as estimator. GenMatch finds automatically the sets of variables minimising the discrepancy between the distribution of potential confounders in treated end control groups (Sekhon 2011). Therefore, it implies that the covariate balance is

maximised by the evolutionary algorithm generation over generation. When in GenMatch, a good propensity score model is considered, while propensity score matching and Mahalanobis matching can be considered as special limit cases of it (Sekhon 2011).

Choosing a Matching Algorithm

Matching estimators are defined as "the simple means of the difference in outcomes over the common support, appropriately weighted by the propensity score distribution of participants" (Caliendo and Kopeing 2008). Estimators differ on how the neighbourhoods are defined, but also by the weight which is assigned to them. According to Khandker et al. (2010), it is recommended to try different matching methods and check the results. Thus, in this research we have compared: Nearest Neighbour with replacement (NN = 1, 2, 3, 4, 5), Caliper (at 0.25 and 0.5), a combination of Nearest neighbour and Caliper (NN = 5, 0.25 and NN =5, 0.5) and GenMatch (Sekhon 2011). Nearest Neighbour matching treated individuals are the closest in term of the propensity score. According to Smith (1997), oversampling (NN > 1) can reduce variance using more information to set up the counterfactual for each participant. Caliper works differently, because it is an estimator that sets a tolerance level on the maximum propensity score distance, improving the quality of the matches. In this case, the match between a treated and non-treated happened in a range of propensity score. GenMatch is a method which automatically finds a set of matches with minimising the discrepancy between the distribution of potential confounders in the treated and control groups (Sekhon 2011).

Matching Quality

Assessing the quality of matching means evaluating how good were matching procedures balancing the distribution in both control and treatment groups. The basic idea is to compare the situation before and after matching. There are several procedures, such as Standardized bias (P. Rosenbaum and Rubin 1985), t-Test, Joint significance and Pseudo-R^2 and Stratification test. Among these procedures, it was chosen to compare the p-value before and after the match. Moreover, it was also run a likelihood ratio test on the joint significance of the test. According to Caliendo & Kopeing (2008), it is in this step that if the model shows a significant difference from one model with a broader set of variables, the model should be rejected after the matching.

5.2.4. Measuring the number of chickens bred by farmers

To evaluate the impact on food availability, we test if the project has an impact on the pure number of chickens bred in the farms. Therefore, the number of chickens has been used as a proxy for food availability. We assume this because more chickens means more meat and eggs for the family both for direct consumption, as well as a income source in case they sold it.

5.2.5.Measuring diet quality: Household Dietary Diversity Score (HDDs)

In this thesis, the quality of the diet is measured through the Dietary Diversity Score focused on Household (HDDs). The HDDs was developed by the Food and Nutrition Technical Assistance (FANTA) Project (Swindale and Bilinsky 2006). Dietary diversity is a qualitative measurement of food consumption (at household level, on average among all members or for individuals) that reflects household access to a variety of foods, and it is also a proxy for nutrient adequacy of the diets (FAO 2013), or the economic ability of households to access a variety of foods (Swindale and Bilinsky 2006). HDDS is an interesting proxy for food security (Swindale and Bilinsky 2006) because:

- A more diversified diet is associated with some improved health indicators, such as birth weight, child anthropometric status, and improved haemoglobin concentration for both mother and children;

- A more diversified diet is highly correlated with nutritional aspects, like caloric and protein adequacy, the percentage of protein from animal sources and household income;

- Therefore, more diversified diet is an important outcome in and of itself;

- Questions on dietary diversity can be easily asked at the household and individual level;

- It implies a more manageable collection of information from the people who were interviewed. Training local staff is relatively easy, and comprehensibility of questions is high. Therefore, completing the questionnaire is rapid, user-friendly and easily administrated.

HDDS is a simple count of the number of food groups consumed in a reference period (Hoddinott and Yohannes 2002). The reference period is usually a 24-hours recall period, but there are other valid timeframes for recall, such as the previous 3 or 7 days (FAO 2013). A more extended reference period results in less accurate information due to imperfect recall.

In general, any increase in household dietary diversity reflects an improvement in the household's diet. The original validation studies (Hoddinott and Yohannes 2002), which carries out a study on ten countries, found that changes in dietary diversity are a good indicator of changes in household per capita consumption and household per capita caloric availability. This is because there is a strong correlation between the two variables: when the diversity increases, also caloric availability increases and vice versa. HDDS is also consistently associated with food expenditure and with various indicators of socioeconomic status (FAO 2008; Kennedy et al. 2010; Thorne-Lyman et al. 2010; Taruvinga et al. 2013).

The food groups proposed[18] by FAO (2013) are summarised in table 5.1, while in table 5.2 and 5.3 the food groups are aggregated to obtain dietary diversity score for household (twelve aggregate groups with potential score 0-12) or individuals (nine aggregate groups with potential score 0-9).

An expanded set of food groups can be utilised to determine the consumption of certain food groups (i. e. vitamin A-rich foods). However, to generate the HDDs, the expanded set of food groups should be combined back in 12 food groups. Data collected can be analysed in several ways. For instance, the score can be analysed to provide information on sub-groups with different demographics or economic characteristics, which are differently stratified (vulnerability, wealth). It could be used to calculate the proportion of a household that consumes a specific food group or to identify different dietary patterns across the population's subgroups.

HDDS is reliable, even if a formal theory that links the number of food groups consumed to levels of either the nutrient adequacy or food insecurity is lacking.

It is difficult to assess how DDS values obtained in different contexts can be accurate and precise indicators of the construct that they are intended to capture (Cafiero et al. 2014). Still, there is no unanimous consensus on an optimal number of food groups, and the computation easiness may lead to errors (i.e. wrong classification of food). Reliability of the classifications can be improved when food groups are adapted to locally available foods (Hoddinott and Yohannes 2002).

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[18] Research is ongoing and there is not unanimous consensus on which food groups have to be included in the scores at the individual or household level for different age/sex groups.

Table 5.1 HDDs food groups (modified by FAO 2013)

Number	Food group	Some Food Examples
1	Cereals	corn/maize, rice, wheat, sorghum, millet or any other grains or foods made from these
2	White roots and tuber	white potatoes, white yam, white cassava, or other foods made from roots
3	Vitamin A-rich vegetables and tuber	pumpkin, carrot, squash, or sweet potato that are orange inside + other locally available vitamin A-rich vegetables
4	Dark green leafy vegetables	dark green leafy vegetables, including wild forms + locally available vitamin A rich leaves such as amaranth, cassava leaves, kale, spinach
5	Other vegetables	other vegetables (e.g. tomato, onion, eggplant)
6	Vitamin A-rich fruits	ripe mango, cantaloupe, apricot (fresh or dried), ripe papaya, dried peach, and 100% fruit juice made from these + other locally available vitamin A-rich fruits
7	Other fruits	other fruits, including wild fruits and 100% fruit juice made from these
8	Organ meat (offal)	liver, kidney, heart or other organ meats or blood-based foods
9	Flesh Meat	beef, pork, lamb, goat, rabbit, game, chicken, duck, other birds, insects
10	Eggs	eggs from chicken, duck, guinea fowl or any other egg
11	Fish and seafood	fresh or dried fish or shellfish
12	Legumes, nuts and seeds	dried beans, dried peas, lentils, nuts, seeds or foods made from these (e.g. hummus, peanut butter)
13	Milk and milk product	milk, cheese, yoghurt or other milk products
14	Oils and fat	oil, fats or butter added to food or used for cooking
15	Sweets	sugar, honey, sweetened soda or sweetened juice drinks, sugary foods such as chocolates, candies, cookies and cakes
16	Spices, condiment and beverage	spices (black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic beverages

Table 5.2 Food groups aggregation for Household DDs (modified by FAO 2013)

Number	Food groups	Number	Food group
1	Cereals	11	Fish and seafood
2	Roots, tuber	12	Legumes, nuts, seeds
3, 4, 5	Vegetables	13	Milk, milk product
6, 7	Fruits	14	Oil, fat
8, 9	Meat, poultry, Organ meat	15	Sugar, honey
10	Eggs	16	Spices, condiments, beverage

Table 5.3 Food groups aggregation for Individual DDs (modified by FAO 2013)

Number	Food groups	Number	Food group
1, 2	Starchy staples	9, 11	Meat, fish
4	Dark green vegetables	10	Eggs
3, 6	Vitamin A-rich fruit and vegetable	12	Legumes, nuts, seeds
5, 7	Other fruits, vegetable	13	Milk, milk product
8	Organ meat		

Also setting HDDS targets is easy. Some authors (Swindale and Bilinsky 2006; FAO 2013) suggest two options:

- Dietary diversity patterns of the wealthiest household can be used as a target under the assumption that the most impoverished household will diversify the dietary in a way which will allow them to get closer to the wealthiest. Therefore, the average HDDs in the wealthiest 33 per cent of households can be used as a guide for setting the target level of HDDs for performance monitoring.
- HDDS target can be established by taking the average diversity of the 33 per cent of household with highest HDDs.

5.2.6. Statistic software

Data was elaborated using R (Team R Core 2018), particularly for the following packages: diplyr (Hadley et al. 2018), tidyverse (Hadley 2017) and Matching (Sekhon 2011).

5.3. Study limitations

The first limitations are the small sample size and the measurement errors occurred during data collection. Measurement errors depended basically on the development context and the scarcity of resources available for the research (both related to skills and team availability). Other problems that could affect the measurement goodness must be sought in the interviewees' characteristics: their level of education is low, thus implying the respondent recall bias and a probably misreporting in the expectation of receiving future support. However, that problem affects both B and NB, so that it should not contribute to bias the results. Despite this fact, some data collected seems not to be completely reliable, especially those related to the production quantity or sold. However, an exception are the food consumption and the number of animals owned, that is much easier to track than the quantity of paddy or fruits harvested, for instance.

The C3S project started in 2012, and it took time to implement the solution that could affect household food security. So, this research began in 2016, covering November 2016 – December 2017 for India, while for DRC it covered January 2017 – February 2018. Thus, this survey can capture only a short-term project impact. Changes in production, as well as in diet habits, take a long time to be kept as a new standard for rural families. Consequently, we should consider that the full development of these impacts may require further years.

Referring to FS analysis, two main limitations have to be pointed out: the HDDs index and the target, namely the household. HDDS is used as a proxy of food diversity, which is related to the family food availability. However, this index is collected only one time in a year and is not able to say something about the coping strategy during the whole year and cannot account for seasonality in diets. Moreover, HDDs do not take into account the food group quantity consumed, which severely limit the comparison among families.

Moving to the household, which is the survey target level, the inquiry is not able to say what happens in the household food share-out. Thus, it is not possible to analyse food security (availability, access or nutrition) for each member of the household, especially for those that very often are the weakness member, such as the mother and the young children.

Concerning the methodology, a possible problem is the spill-over effects, namely sample contamination from B households to those that are NB. That is possible especially in India and

very unlikely in DRC. In India, even if families B and NB belong to the same tribe, they belong to different family groups. It is more plausible that information passes through families that belong to the same self-help group instead of families that are not involved in the same group. However, the possibility still stays on the table and NB families may directly or indirectly benefit from the exposure to the PC intervention. This fact hinders the attribution of effects to the project. In light of this consideration, we can assume that if the spill-over happened, it should be considered positive because it may produce changes in the direction of the purposes of the project. So, it is possible that the results underestimated the program effect. That lead to two consideration. If the results are significant, the project effect could be underestimated. In case of no significant difference in the results, it is not possible to bring to a conclusion because of the impossibility to separate the impact from the spill-over effect.

5.4. Summary

The goal of this chapter has been to describe the research design, data collection and methods both in India (Darenchigre and Bajangoba) and in DR Congo (Kabinda). The study area in India is mainly rural, while in DR Congo it is mainly suburban. Due to the ex-post design of the study, several problems were encountered. There was the difficulty to find local experts in scientific survey methodologies both in India and Congo. Also, the lack of local organisational skills of the pilot centre team required much time to collect all the necessary data accurately. Another problem has been the interaction with the rural people while trying to translate the scientific meaning of questionnaires easily understandable by the target population. Therefore, the selection of households was not exclusively random.

Nonetheless, it was possible to interview 198 households in India and 83 in DRC, which made possible to perform statistical analysis. The following chapter will describe the evaluation of the C3S project; chapter 5 is dedicated to research carried out primarily in India, and chapter 6 is dedicated to DR Congo. Finally, chapter 7 will summarise the results.

6. Analysis of C3S project in India

According to the introduction chapter in which the research objective and hypothesis has been described, the purpose of this chapter is to test the hypothesis:

The project has been able to enhance the food security among smallholder families that are involved in the project in Darenchigre, Meghalaya State, India.

To test the hypothesis, two assumptions need to be verified: i) the project C3S has intervention or strategies able to affect the food security level of smallholder families and ii) it is possible to collect sufficient information to describe the nutritional status, food production, foodstuff conservation, economic and social situation in India and evaluate the impact between the beneficiary and non-beneficiary.

Therefore, this chapter is organised into three sections. Section 1 is the introduction, where it recalls the hypothesis, which has to be tested. Section 2 is a discussion on the first assumption in which the sub-hypothesis 1, 2, 3 are verified. The following third part focus on the test on sub-hypothesis 4, namely food availability, sub-hypothesis 5, namely food access (section four), where data, results and discussion are presented.

6.1. Interventions and strategies of C3S project

In theory, a household in the study area can attain food security from either domestic production (food availability, namely field, animal and fish production) or purchasing from the market (food access) or a combination of both (Nyariki et al., 2002). Thus, the C3S project should design intervention that aims to improve domestic production and/or the food access to assess an overall improvement of food security (either quality and quantity).

According to the sustainable intensification frameworks suggested by FAO (FAO 2011b; OECD and FAO 2018) project, C3S should take into account the concept of Sustainable Diet (FAO 2010) according which other than the three pillars of sustainability (economic, social and environmental).

Data for the analysis were collected from internal reports, mission reports and informal interview with the project coordinator and managers, other than bibliographic research (Bertoni et al. 2015, 2016; Minardi et al. 2015; Ndereyimana et al. 2018).

Intervention is described according to the following aspects: object, target, approach and results (research or implementation on the field). In table 6.1, we summarise the intervention divided into food availability, accessibility and sustainability (environmental, social and economic) areas.

Table 6.1 Summary of project C3S interventions divided by focus: food availability, food access, sustainability

Area	Intervention	Object	Target	Approach	Phase
F. Availability					
	Plant production				
	Rice production	Improving Rice	Farmers	Plot demo	On the field
	Veg. Garden	Improving VG	Women	Plot demo	On the field
	Fruits trees	Trees Management	Households	Plot demo	On the field
	Cover crops	Fertilization	Farmers	Plot trials	Research
	Vermicomposting	Fertilization	Farmers	Trials	Research
	Mushrooms	Mushrooms production	Household	Demo	On the field
	Animal Husbandry				
	Poultry breeding	Meat and egg production	Households	Training	On the field
	Pigs breeding	Improve meat production	Households	Trials	Research
	Cow breeding	Milk production	Households	Trials	Research
	Storage	Reduction of losses	Households	Trials	Research
	Water sanitation	Improving the quality of water	Women, child	Trials	Research
F. Access					
	Diet diversity	Improving the quality of diet	Women, child	Training	On the field
	Food				
	Processing food	Selling snacks at the market	Women	Training	On the field
	Bakery	Bakeries production	Women	Training	On the field
Sustainability					
Environmental	Domestic fires	Reduce air pollution	Household	Trials	Research
Environmental	Open defecation	Reduce water pollution	Household	Enquiry	Research
Social	Women farmers Club	Social cooperation	Women	Teamwork	On the field
Economic	Income Gen. Activity				
	Tailoring & Wavering	Produce tailormade tissue	Women	School	On the field
	Rosary	Produce Rosary	Women	Training	On the field

6.1.1.Strategies to improve the availability of food

Intervention on plant production:

- Rice production: the objective was ameliorating the traditional rice production; namely using improved rice seed, provided by the Krishi Vigyan Kendra research centre as well as by improved management. The target was local farmers that usually grow rice. The approach was demonstrative, planting the new variety with improved management in the plot closer to allow the comparison between traditional variety and methods. The result is an implementation on the field but, due to the scepticism that new practices arose, the adoption is progressing slowly. Farmers choose to try new variety and management on little plots. Therefore, until now there is no significant evidence on the adoption;

- Vegetable garden production: the objective was to improve the household winter vegetable garden with improved crops and techniques, as the management of wells water in the winter season. The target was household women that usually are in charge of the vegetable garden. The approach was demonstrative, planting a vegetable garden at the Pilot Centre, promotion of knowledge on best practices on the vegetable garden (i.e. the distribution of improved seeds and seedlings). The team of PC promote a contest on the best Vegetable garden, in which the winner received, as a prize, tool for gardening. According to the report, the initiative was positive; as a result, this intervention was implemented in the household's fields;

- Fruits production: the objective was to ameliorate the quality of household orchards (to improve the diet), focusing on trees' correct management (pest and disease management and pruning). Target is households interested in trees production. PC has provided a demonstration field with several trees (citrus fruits, banana, guava, mango), some seedlings of ameliorated varieties and training for proper management by people from the KvK of Tura. Thus, the intervention has been reaching the stage of diffusion on the field. The initiatives were well welcomed;

- The proposed agreement with Block Development Office of Tikrikilla. Target is the vegetable garden owner, and the approach is trials combined with community training. So far, the adoption of such technique proceeds slowly because of the complexity of the process;

- Cover crops: Since the needs of fertilisation is an important issue, PC according to a trial suggested by the Plant production unit, tried to select the most promising cover crop

to seed in the vegetable garden. The targets are both rice grower and household. Nowadays, the trial is in a research phase.

- Vermicomposting: to address the lack of affordable fertilisers in Darenchigre market, PC promotes the domestic production of vermicompost. The farmers and women that take care of the vegetable garden are the targets of intervention. This intervention was implemented as theoretical training (meeting with an expert on compost production) and practical activity predisposing a trial field at the PC. To date, the intervention is on the field stage.

Mushrooms

- Pilot Centre promoted the consumption of homemade mushrooms, which can also become an exciting activity an income diversification besides the dietary diversification. Due to the simple technology (a bag with inoculum is hanging from the ceiling, and every day it was kept moist), the local team hopes for a natural diffusion. Target is a household, and the approach is demonstrative. Nowadays this intervention is in the research phase;

Animal husbandry

- Poultry production: the objective was to improve meat and eggs production, through the introduction of the improved a chicken breed, Kuroiler. Kuroiler is an improved breed obtained from a research centre based in India. Pilot Centre bought chicks which have been sold a mouth later after vaccination cycle to farmers, providing knowledge on proper management. The Kuroiler diffusion was implemented on the field well welcomed by the local farmers, and in some households, the hens were able to increase the eggs production significantly;

- Pig production. Through proper diet control and management of the animals, the Pilot Centre staff has tried to improve the traditional diet both on traditional and ameliorate pig's breeds. This intervention is in the research phase. The final target is pig's farmers;

- Cow production. As for pigs, cow breeding is characterised by low production, mainly due to low genetic merit and an unbalanced diet, besides improper management. According to guidelines provided by the Italian researchers, the trials aim to increase milk production (quantity of milk per day and lactation length). So far, the intervention is at the research phase.

Storage

- Losses (both quality and quantity) due to inefficient storage methods (against insects and rodents) are common among households. To address this issue, a new type of plastic bags was tested. The bag has multilayer plastic sheets that inhibited the oxygen passage into the bag and isolated the scent of grains or pulses. This double action contrast insects that cannot survive in anaerobically environment as well as rodents avoiding smell release and their attraction to the food. Nowadays, the intervention is on the research stage.

Water Sanitation

- The intervention aimed to get safe water for human consumption (drinking, cooking). Targets are women and children. PC team tested shared ceramic candle filters and slow sand filters, starting from the construction till to the tuning. These last filters are easy to handle and not expensive to set up. Nowadays, the intervention is in a research stage.

6.1.2.Strategies to improve access to food

These strategies are related to increasing the awareness of diet and the income to get more balance diet through the market.

Diet diversity

- The purpose of the intervention is to raise dietary diversity, increasing the food groups consumed by the family, especially those derived from animal production, as well as fruits. The targets are women who are responsible for household food preparation and children at the school. Pilot Centre team promote Awareness Program, both in the villages or at the Pilot Centre. The awareness program created has the opportunity for the PC to keep in contact with an expert on nutrition and physicians.

Food

- Processing Food: the object of the intervention is the processing of food to prepare marketable snacks or for home purposes. Women are the target and Pilot Centre provides training for skills, along with tools for manioc or plantain chips preparation. Part of generating income returns to the Pilot Centre to provide further raw material. To date, a kiosk close to parish school is the point of sale for these snacks.
- Bakeries: make available a community wood oven for bakery production. Families that live close to the parish are the targets of the intervention. PC directly promoting and financed (as microcredit) the building of the wood oven, (which is protected by a bamboo structure) and training for bread and cookies production. Part of generating income

retunes to the Pilot Centre to provide further material and pay construction costs. To date, the oven is in quickly growing business which ables the bakers to refound the financing.

6.1.3.Sustainable Strategies

Domestic fire

- The object of intervention is the reduction of smoke pollution, also inside the household, due to an efficiency' increase in a domestic fire. The advantages are multiple: reduction of illness related to smoke (i.e. eye irritation, respiratory diseases) improvement of the air inside the house, reduction of wood as fuel. Both women and the head of household are the targets. Two approaches pursued: diffusion of improved domestic fire trying to replace the three-stone fire and to test new cookstove. In both cases, the results are in elaboration, but still at the research stage.

Open Defecation

- Local team enquiry the status of toilet facilities available for household trough questionnaire, trying to understand the impact of open defecation (especially in shallow waters). The targets are households as a whole. Nowadays, the intervention is in the research phase.

Women Farmers Club

- This intervention aims to strengthen the social cohesion among women that are employed in agriculture, providing support and sharing information. Women are approached through social meetings, awareness program, visiting on plot and vegetable garden by the local team of PC. Project supply also some inputs, such as ameliorated seeds and seedlings. Thus, the implementation is in the field.

Income Generating Activity

- Tailoring and weaving: create an income-generating activity for women through tailoring and weaving activity. Traditionally, Garo women know how to make fabrics and to tailor-making clothes. In the recent period, this activity was overlooked. Pilot Centre bought sewing machines and recruited a tailoring teacher. The PC also financed put back into operation the traditional looms. Nowadays the tailoring school is inactivity and produce goods.

- Rosary: create an income-generating activity for women through the assembling of rosaries. Pilot Centre bought the raw material and provided a room for the activity as well as the selling at the market. A trainer guides women and set up rosaries. Part of

generating income retunes to the Pilot Centre to provide the further raw material. Thus, intervention is ongoing.

In conclusion, the project has implemented the initiatives in improving food availability, through enhancing production and storage methods and food access. Concerning food access, the intervention pursued two different approaches. One approach was based on the increase the awareness on Sustainable diets, while the other focused on generating income to get more access to the food into the local market. Finally, we listed also the interventions that are related to the theme of sustainability. Even if these interventions played a significant role in improving the quality of life of the households, their evaluation is outside the present research project. That decision was made due to the limitation of data collected, which they do not allow us to perform a robust scientific analysis. Therefore, in the next sub-chapter will be discussing only the evaluation of food availability and access made by the project.

6.2. Evaluation of the impact on smallholder farms Food Security

In this section will be presented the analysis on the project's impact of food availability and food access intervention made by the C3S Project. To perform the analysis, we collect 193 questionnaires, sorted in 112 non-beneficiaries (NB) family and 82 Beneficiaries (B).

Food Availability

As discussed before, plant and animal products can be mentioned among the actions on food availability promoted by the C3S project (Bertoni et al. 2015). Intervention on plant production is taking time to be implemented because of the long-time needed to show the possible improvements since farmers tend to be very cautious in the adoption of novelties.

On the other hand, animal production intervention (at least for chickens) appears faster than plant production and the data collected have tried to be more reliable in quality and quantity than rice production. So far, the purpose of this evaluation is to estimate the impact of the project on chicken breeding, derived from poultry intervention. The intervention is based on two pillars: training on poultry management (health, diet) and distribution of improved Indian chickens breed (Kuroiler) after immunisation against the riskiest diseases. The comparison among beneficiaries and non-beneficiaries is on the number of the traditional chicken bred by the farmers to evaluate the goodness of the intervention.

Food Access

C3S project promotes the awareness program to population and among children at the parish school (Bertoni et al. 2015). To give an idea of nutritional status in India, C3S team elaborated data from two surveys (2013 and 2018) and reported deeply in the thesis of André Ndereyimana (Ndereyimana 2016). In this section, the most interesting fundigs related to malnutrition among Garo's will be presented. The under-five year's infant nutritional status in the Indian project area has been evaluated through anthropometric method (Reinhard and Wijayaratne 2000). Single measurements regarding height (cm), weight (kg), sex and age (months) have been recorded. In both 2013 and 2018, an appropriate method has been used to collect anthropometric data of a representative sample of 110 children, a third of them from families involved in the C3S project and the remaining not involved. Then, the data have been analysed according to the World Health Organization new growth standards (WHO 2006). Thus, stunting (chronic malnutrition), wasting (acute malnutrition) and global nutritional status (sum of stunting and wasting) indicators have been determined. Comparison has been made between data collected in 2013 and those of 2018. Subsequently, data comparison of children belonging to families that participated in the projects against those that did not participate has been made. In both cases, the last data were collected in January 2018 (after five years of the project implementation). Height-for-age z-scores (HAZ) is corresponding to stunting, weight-for-length or height z-scores (WL/HZ), is corresponding to wasting, and weight-for-age z-scores (WAZ)[19] is corresponding to global nutritional status. For each one of the above three nutritional status indicators, four different classes are suggested; the first three are severe and moderate malnutrition, or normal nutritional status which z-scores are respectively < - 3, between - 3 and – 2, between -2 and 2. The 4th class correspond to values above 2 (over), either for weight or height (overweight). Results comparing the nutritional status of the children within the first five years of life in 2013 versus 2018, separating the subjects in two age clusters (0-2 years and 3-5 years), are shown in table 6.2.

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[19] The determination of the different z-scores of each nutritional status indicator has been performed using a series of mathematical calculations that take into account the not normally distributed values as described by WHO (2006) in the reference population. Thus, the so-called LMS formula were used to calculate z-scores height-for-age (HAZ), weight- for-age (WAZ), weight-for-height or weight-for-length (WH/LZ) as described in this formula: **z-score= ([(observed value / M)]^L-1)/(L ×S).**
In this formula, M, L and S are values for the reference population. M is the reference median value which estimates the population mean for each single measurement (weight, height or length and age). L is the power needed to transform the data to remove skewness (i.e. to normalize the data). S is the coefficient of variation (or equivalent).

In that table, the number of the surveyed children (n) and the share (%) of the magnitude of each nutritional status indicator are showed. The first cluster (0-2 years) is mainly used as a "proxy" predictor of the long-term impairment of cognitive capacities development, and it is mainly due to mother malnutrition as well as insufficiency of baby care in that tender age (Black et al. 2013). The second age cluster is suggested as an indicator of household food and nutrition security as well as other related socio-economic conditions (namely the level of nutritional knowledge of mothers). Indeed, the 3-5 years age cluster (post-weaning) has been demonstrated to be more critical from a nutritional point of view, particularly in poor communities, because mother milk was stopped, and the available foods are those for adult people (Ndereyimana 2016).

Table 6.2 Anthropometric indicators of chronic malnutrition (HAZ); acute malnutrition (WHZ) and global malnutrition (WAZ) of Indian children.

NSC*	0-2 years				3-5 years			
	2013	2018	2013	2018	2013	2018	2013	2018
HAZ								
	n		%		n		%	
SCM	38	30	43	70	42	26	31	40
MCM	6	7	7	16	9	18	7	28
NNS	31	4	35	9	73	21	54	32
OV	14	2	16	5	12	0	9	0.0
Total	89	43	100	100	136	65	100	100
WL/HZ								
SAM	9	3	11	7	1	0	1	0
MAM	6	3	7	7	5	4	4	6
NNS	38	28	45	65	66	59	51	91
OV	31	9	37	21	58	2	45	3.1
Total	84	43	100	100	130	65	100	100
WAZ								
GSM	15	16	17	37	3	7	2	11
GMM	8	7	9	16	10	19	7	29
GNNS	56	20	63	47	112	39	82	60
OV	10		11	0	11	0	8	0
Total	89	43	100	100	136	65	100	100

NSC: Nutritional Status Classes

From the table 6.2, we can observe that the trend of the different indicators is not the same for the children the nutritional status in the last 5 years is different (i.e. the normal subject = NNS in 2018 were 32% vs 54 % for HAZ, while for WL/HZ were 91% vs 51 %). This is perhaps attributable to their meaning (HAZ for an extended period of malnutrition and WL/HZ for short

one), which are maybe related to the different environmental conditions that in 2013 vs 2018 affected the nutritional status. In fact, for both years clusters, the chronic malnutrition (HAZ) was lower in 2013 than in 2018, with 43 vs 70 % (0-2 years) and 31 vs 40% (3-5 years) respectively for the severe one (SCM); as well as the moderate class (MCM) with respectively 7 vs 16% and 7 vs 28%. An opposite trend is observed for normal nutritional status (NNS) with 35 vs 9 % and 54 vs 32 % respectively in 2013 and 2018. The same is true for overweight children, for both clusters higher in 2013 vs 2018.

As regard to wasting or acute malnutrition (WL/HZ), table 6.2 shows four levels data too: severe (SAM), moderate (MAM), normal nutritional status (NNS) and overweight (OV). For this indicator, the trend is different concerning HAZ; namely, better nutritional status was observed in 2018 than in 2013, mainly for SAM (reduced malnutrition) and for NNS (increasing in both 0-2 years: 45 vs 65% and 3-5 years 51 vs 91 %). This short-term better situation in 2018, cannot be attributed to the period in which the anthropometric data have been collected; for both years, the data collection was in springtime. Therefore, the rice harvest period, the main staple food, was relatively recent. Otherwise, the infant overweight was reduced in 2018 than in 2013 in both clusters: 0-2 and 2-5 years (table 6.2). These results could suggest that some improvement in the nutritional status occurred between 2013 and 2018.

As regards to global nutritional status (WAZ), the trend is similar to that found in chronic malnutrition levels (HAZ) with a better situation in 2013.

These differences could mean that better indicators of malnutrition are those including age, no matter if the height or weight are considered (in some extent are related); for the same reason, the indicator WL/HZ appears less useful. Nevertheless, this general comment could be inappropriate because Wasting index is useful in any case to evaluate the short period effects on nutritional status; furthermore, in our case, the comparison of indices including age, could be negatively affected by the less precise evaluation of age in 2013 (the age was recorded in years instead of in months like in 2018). Thus, it is difficult to conclude if over the last five years, the infant nutritional status has been improved or not.

6.2.1. Variables Description

So far, the purpose of this evaluation is to estimate the impact of the project on a number of chickens bred and the diet diversity, derived from training and awareness programme operated by the PC. In this paragraph, the topics presented in general terms in chapter 5 are recalled and analysed in depth. More precisely, the variables chosen for the evaluation will be

presented and the data used to calculate HDDs discussed. The first sets of variables are the outcomes variables, namely the number of chickens and the Household Dietary Diversity Score. The second set is the variables chosen to perform the propensity score matching.

Animal Husbandry

Referring to the previous years, the enumerators asked information on animal breeding. In particular, the number of cows, chicks, pigs, goat owned (for all type, traditional or improved), along with other information useful for the project to develop proper training. In table 6.3, the results of the enquiry are summarised.

Table 6.3 Household involved in animal breeding divided into beneficiaries and non-beneficiaries of C3S project

Variables	Non-Beneficiaries				Beneficiaries			
	N° of HH	% of the total HH	N°	SD	N° HH	% of the total HH	N°	SD
Cow	60	53.6	3.08	1.95	66	80.5	3.18	1.74
Chickens	91	81.3	15.06	9.22	80	97.6	17.6	13.74
Pig	76	67.9	2.28	2.04	64	78.0	2.38	1.50
Goat	4	3.6	2.5	1.73	12	14.6	3.5	2.06
Livestock Unit	99	88.4	1.44	1.25	82	100.0	1.87	1.23

The sampled households showed a particular interest in husbandry. In facts, 99 families that are not involved in the project (out of 112) and 82 beneficiary households are involved in animal husbandry. The average Livestock Unit (LU) is 1.44 ± 1.25 for non-beneficiaries, while LU is 1.87 ± 1.23 for beneficiaries. The most important species bred by the household interviewed are chickens, cows and pigs. Households that bred goats are present but in a smaller number. The chicken breeding is by far the most widespread husbandry activity in both B (97.6% of the family with 17 ± 13 chickens) and NB (81.3 and 15 ± 9). Both B and NB tend to breed more species simultaneously (table 6.4).

Table 6.4 Animal Husbandry divided into beneficiaries and non-beneficiaries of C3S project (2017)

Variables	Non-Beneficiaries		Beneficiaries	
	N°	%	N°	%
Number of bred Species				
0	13	11.6	0	0
1	15	13.4	8	9.8
2	37	33.0	17	20.7
3	45	40.2	48	58.5
4	2	1.8	9	11.0

Garo's Diet

Garo's diet habits consists of two essential meals during the day, namely breakfast and dinner; meanwhile, lunch is something more frugal. HDDs by household is computed as the sum of the food categories consumed. Each food category has values which equal 1. The respondents, which are the head of household, or the spouse provided information about the type of food consumed during the recalling week for the entire household. The data collected has been re-organised in the 12 HDDs categories and then summed (table 6.5).

Table 6.5 12 HDDs categories consumed by the household beneficiaries and non-beneficiaries of C3S - Darenchigre

number	Food groups	Non-Beneficiaries		Beneficiaries	
		N	%	N	%
1	*Cereals*	112	100	82	100
2	*White roots and tuber*	112	100	82	100
3	Vitamin A-rich vegetables and tubers	56	48.6	51	62.1
4	Dark green leafy vegetables	60	52.1	71	86.6
5	Other vegetables	112	100	82	100
6	Vitamin A rich fruits	66	57.4	73	89
7	Other fruits	66	57.4	73	89
8	Organ meats	na	na	na	na
9	Flesh meats	100	86.9	81	98.8
10	*Eggs*	57	49.6	53	64.6
11	*Fish and seafood*	111	99.1	79	96.3
12	*Legumes, nuts and seeds*	110	98.2	75	91.5
13	*Milk and milk production*	46	40.0	37	45.1
14	*Oils and fats*	110	98.2	78	95.1
15	*Sweets*	108	93.9	75	91.5
16	*Spices, condiments and beverages*	112	100	82	100

na: not available

Rice and other starchy foods are usually own produced. Meanwhile, pulses vegetables, fruits and animal proteins are purchased from the market. These results seem consistent with Bertoni et al. (2015). The most common source of proteins is fish. Meanwhile, meats and other animal product are rarer — especially eggs, which farmers do not commonly produce.

Table 6.6 presents the HDDs score, ranked by the smallest to the most prominent. At the household level, mean dietary diversity is 10 (9.8) for NB and 11 (10.7) for B; that is in the

average NB household has consumed ten food groups during the reference week while average B household has consumed eleven food groups during the same reference week. This value is higher if compared to those provided by Koppmair et al. (2017) in rural Malawi.

Table 6.6 Household ranking according to HDDs divided into beneficiaries and non-beneficiaries of C3S - Darenchigre

HDD score	Non-Beneficiaries		Beneficiaries	
	N	%	N	%
7	1	0.9	0	0
8	9	7.8	4	4.9
9	35	30.4	6	7.3
10	16	14.0	15	18.3
11	19	16.5	35	42.7
12	35	30.4	22	26.8

Since there are no universal cut-offs for HDDs categorising (Swindale and Ohri-Vachaspati 2005; Pauzé et al. 2016) in table 6.7 food groups are classified in three levels to provide information on dietary patterns according to the food groups consumed by at least 50% of the household in each tercile.

Table 6.7 Food groups consumed by ≥ 50% of the household by dietary diversity tercile - Darenchigre

Low < 9	Medium ≥ 9 11 ≤	High > 11
Cereals	Cereals	Cereals
White roots and tuber	White roots and tuber	White roots and tuber
Fish and seafood	Fish and seafood	Fish and seafood
Vegetables	Vegetables	Vegetables
Legumes, nuts and seeds	Legumes, nuts and seeds	Legumes, nuts and seeds
Oils and fats	Oils and fats	Oils and fats
Sweets	Sweets	Sweets
Spices, condiments and beverages	Spices, condiments and beverages	Spices, condiments and beverages
	Fruits	Fruits
	Flesh meats	Flesh meats
		Milk and Milk product
		Eggs

In the lowest (<9), the nine groups of food are cereals, white roots and tuber, vegetables, legumes, nuts and seeds, oils and fats, sweets and spices, condiments and beverages. In the second tercile (9-11), families should introduce fruits and fresh meat in the weekly diet. In the highest tercile (12), families add milk and eggs.

Choice of variables for Estimating Propensity Score

To elaborate the propensity score matching it is necessary to identify the variables which i) allow the comparison between beneficiaries and non-beneficiaries, and ii) affect both participation in treatment and outcome simultaneously (Caliendo and Kopeing 2008). The variable choice has been made, taking into account the program-specific activities and aims in light of economic theory. As a result, both theoretical and empirical sources have been consulted. From previous research, we focused on findings which adopted the matching approach on agriculture activities. Matching techniques have been widely used in several impact studies of rural development and agricultural technology. (Gitonga et al. 2013; Shehu and Sidique 2014; Brunie et al. 2014; Shiferaw et al. 2014; Zeweld et al. 2015; Wordofa and Sassi 2017). Based on these considerations, we included the following variables (table 6.8) to estimate the propensity score:

- Set "head of household" (HH), which is composed by: age reported in actual years, employment status (if HH has a sort of guaranteed income or an occasional job), employment in agriculture (if the HH is involved in agriculture) and level of education (if the HH attended no school, primary, secondary or more than secondary);

- Set "spouse", which includes, employment status (if she has a sort of guaranteed income or an occasional job), employment in agriculture (if the spouse is involved in agricultural activities), level of education (if the spouse attended no school, primary, secondary or more than secondary);

- Set "Household", which incorporate: family size (number of people that live in the same dwelling and share at least one meal per day), number people that work in the family, male/female ratio in the family. If the family grows rice either for subsistence or business, number of cash crops that family grows (such as betel, areca nuts, rubber, pepper and fruits trees plus pineapple) and whether or not the Pilot Centre's Coordinator knows the family;

- Set " wealth", which encompass: agriculture as first source of income of the family (yes, no), annual income made by the two most important source of income (Indian rupees),

hectare invested in paddy rice, rice-cultivation status (yes, no), Livestock Unit owned (number), quality of the toilet facilities (medium: yes, no; bad: yes, no);

- Set "logistic", which include the means of transport, namely if the family owns bicycle (yes, no) or motorcycle (yes, no), and the distance between the dwelling of the household and Pilot Centre (in kilometres)

Table.6.8 Hypothetical explanatory variables used in the first step to estimate the participation into the C3S project and their expected outcomes - Darenchigre.

Instruments	Description	Type
Dependent variables		
Participation in C3S project	Involved status: 0= not involved, 1=involved	Categorical (dummy)
Variables		
HH age	Age of household in years	Continuous
HH employment status	Employment status 0= not employed, 1= employed	Categorical (dummy)
HH employed in agriculture	Agricultural employment status 0= not employed, 1= employed	Categorical (dummy)
HH Education status	Level of education	Continuous
Spouse employment status	Employment status 0= not employed, 1= employed	Categorical (dummy)
Spouse employed in agriculture	Agricultural employment status 0= not employed, 1= employed	Categorical (dummy)
Spouse Education status	Level of education	Continuous
Household size	Numbers of household members	Continuous
Number of workers in the family	Numbers of household members that works	Continuous
Male/female ratio	The ratio of male to female members of the household	Continuous
The first source of income	Agricultural activities are the first source of income 0= no, 1= yes	Categorical (dummy)
Household Income	Total household income	Continuous
Total farm size	Actual farm size in hectares	Continuous
Rice cultivation	Household grows rice 0=no, 1=yes	Categorical (dummy)
Cash crops	Number of cash crops grows by the family	Continuous
Livestock Unit	Livestock unit owned by the household	Continuous
Toilet	Type of toilet	Continuous
Means of transport	Possession of means of transport 0= no, 1=yes	Categorical (dummy)
Distance from Pilot Centre	Distance between household and Pilot Centre	Continuous
Coordinator know the family	Coordinator knows the household 0=no, 1=yes	Categorical (dummy)

6.2.2.Results

The descriptive statistics shown in table 6.9 highlight that between beneficiaries and control groups, there is some statistically significant difference. We can see that being employed in agriculture and having the first income from the agricultural activity is positively correlated to participation. That is conceivable due to the project's agricultural aim. On the other hand, annual income and assets possession, such as bicycles, motorcycles and toilet, are negatively correlated to participation.

Most likely, this is because of the relative wealth and the presence of other more lucrative economic family activities among NB. The land size appears not to be an essential participation factor as the crop cultivated. Rice cultivation is positively correlated to the participation; meanwhile, cash crops appear uninfluential.

As mentioned before, family farmers without paddy field are the new one, that did not receive from the village plain land (due to the scarcity of appropriate land). Instead, they receive hill land, where is possible to manly cultivate cash crops. Finally, families who are involved in livestock production seem more inclined to participate in the Pilot Centre training. This could be interpreted as a sign of interest from farmers to improve their animal husbandry as a source of income as well as a source of food.

It is worth paying attention to some other variables. About employment, meaning that if the HH has a sort of "certain" income, 80.9 % among NB has one of it, meanwhile, this percentage grow up to 96.3 % among B. The 40.9 % of NB are employed in agriculture compared with 65.9% of B. The education level shows some differences: NB has member equally distribuited in each class, menawhile B attended mostly the primary class. This evidence is unusual. Due to the type of data collected we are unable to speculate on the reason for this situation, also taking into consideration the type of work that respondents have stated.

About the spouse, a large percentage of spouses are employed in agricultural as significant activity (48.8% B compared to 47.8 % NB). The shape of the education level of the spouse follows the same tendency of HH.

Moving to household data, the size of the families is quite similar (5 ± 1.9 for NB and 5.7 ± 1.9 for B), as well as number of working people per family (2.5 ± 1.1 NB and 2.7 ± 1.2 for B) and the male/female ratio (1.1 ± 0.9 for NB and 1.1 ± 0.8 for B).

Table 6.9 Descriptive statistics – the socioeconomic status of households sorted by B (82) and NB (112) - Darenchigre

	Variables	Non-Beneficiaries	SD	Beneficiaries	SD	P Val
Head of Household	Age (years)	43.9	11.4	43.8	9.45	***
	Employment (%)	80.9		96.3		***
	Employed in agriculture (%)	40.9		65.9		***
	Education (%)					
	No school	27.8		22.0		
	Primary	27.0		52.5		
	Secondary	20.9		19.6		
	Tertiary	24.3		6.1		
Spouse	Employment (%)	47.8		48.8		*
	Employed in agriculture (%)	27.8		34.1		***
	Education (%)					
	No school	26.5		29.3		
	Primary	32.7		51.2		
	Secondary	25.7		18.3		
	Tertiary	15		1.2		
Household	Size (number)	5.02	1.87	5.73	1.90	ns
	Worker (number)	2.53	1.12	2.67	1.20	ns
	Male/female ratio (number)	1.14	0.85	1.05	0.72	ns
	Agricultural as the first source of income (%)	23.5		29.3		**
	Income pro capita (Indian Rupees)	16,449	11,322	11,089	7,135	***
	Rice cultivation (%)	41.7		72.3		***
	Land cultivated %					
	no	1.7		6.1		
	0.1 ha – 0.4 ha	57.4		64.6		
	0.5 ha – 0.8 ha	20		15.9		
	0.8 ha – 1.2 ha	7		9.8		
	> 1.3 ha	13.9		3.7		
	Cash crops (%)					
	0	7		2.4		
	1	12.2		22		
	2	29.6		40.2		
	3	38.3		29.3		
	4 or more	13		6.1		
	Livestock unit (%)					
	0	1.7		6.1		
	0.1 - 0.4	57.4		64.6		
	0.5 – 0.9	20.9		18.3		
	1 – 1.4	11.3		7.3		
	1.5 – 0.9	2.6		2.4		
	> 2	6.1		1.2		
	Type of toilet (%)					
	medium	49.6		93.9		***
	bad	7.8		4.8		ns
	Possession of Bicycle and Motorcycle (%)					
	Bicycle	53.9		67.1		*
	Motorcycle	25.2		11		*
	Distance from Pilot Centre (km)	2.30	1.6	2.24	1.5	ns
	Coordinators know the household (%)	86.1		100		*

Despit large number of HH employed in agriculture among beneficiary families, only 29.3 % has declared agriculture as the first source of income. Meanwhile, among the non-beneficiaries, the percentage is decreased to 23.5 %. Income per capita, obtained as the sum of the two most important source of income stated by the family divided per the family size, shows an important difference 16,449 ± 11,322 Indian Rupees for NB and 11,089 ± 7,135 Indian Rupees for B. Self-consumption in families that rely on agricultural income as a first source is a fundamental contribution to the household economy. Unfortunately, we are not able to elaborate any evaluation on how much this can impact on finances. So, we integrated this information whit others, such as the property of motorcycles, as wealth indicator. Rice cultivation is more widespread among B household (72.3%) than NB household (41.1%).

The breakdown of families based on cultivated hectares (not only rice) is similar between B and NB. The large part of families has cultivated from 0.1 to 0.4 ha (57.4% for NB and 64.6% for B). To obtain proper information is, however, quite complicated because usually, farmers do not measure the size of land that they cultivate (Lahiri and Das 2012). Despite that, it seems that data obtained from the questionnaire are confirmed by those collected by the government of Meghalaya (Government of Meghalaya Department of Agriculture 2005): 26.11% of landholders is in the <0.50 ha class, and the 29.23% in the 0.50-1.00 ha class.
The number of cash crops is another essential variable used as a proxy of wealth. Typical cash crops in this area are a pepper, betel, areca nut, rubber, fruit trees (such as banana) and pineapple. A few households state no cultivations of cash crops (7 % of NB and 2.4 % of B).

The distance between the Pilot Centre to the dwelling is similar for both NB and B 2.30 ± 1.6 km for NB and 2.24 ± 1.5 km for B. Coordinator knows all the families involved in the project, while, the percentage fall up to 86.1 % for NB.
A relevant unit of measure that was used to matching the families is the Livestock Unit (LU). This is a reference unit, which aggregates livestock from different species and age as per convention, applying specific coefficients based on the nutritional requirement for each type of animal. Since the project is running in a developing country, in this research, it has been utilised the coefficient proposed for South Asia by FAO (2011) to calculate LU: 0.5 for cattle, 0.01 for chicken, 0.20 for pigs and 0.10 for goat. Livestock unit calculated in this way allows a direct international comparison. As can be seen from table 6.4, LU depends foremost on the

number of cattle raised; meanwhile, chickens have the smallest coefficient. Both B and NB showed the same modal value, equal to the class 0.1-0.4 LU (57.4 % NB and 64.56%)

The variables are organised in a different set of groups to estimate the quality of the model. The groups are: *Full specification*: all the variables; *household*: size, worker, male/female ratio, rice cultivation, number of cash crops, coordinators know the household; *head of household* (employed, employed in agriculture, level of education, age); *Spouse* (employed, employed in agriculture, level of education); *Wealth indicator* (agriculture as first source of income, annual income, toilet, land size, livestock unit); *logistics* (distance, possession of bicycle and motorcycle).

Given all these set of variables, we performed a test to estimate the quality of the statistical model in order to identify the set of variables that fit better. The parameters utilised are the Akaike information criterion (AIC), which is an estimator of information losses and the confusion matrix. AIC is used to test the model capacity to classify accordingly, participant and non-participants to the project. The results are shown in Table 6.10.

Table 6.10 Variable sets evaluation using AIC e confusion matrix - Darenchigre

	Model	AIC	NB %	B%	TOT %
1	Full specification	211.9	93	68	82
2	Without household	211.8	89	61	77
3	Without the head of household	207.3	91	65	80
4	Without spouse	212.2	90	70	81
5	Without wealth indicator	237.1	89	48	72
6	Without logistics	211.8	88	66	79
3-4	Without the head of Household and Spouse	201.0	88	60	75

Comparing the models, those without HH and spouse covariates appear the best solution. Therefore, we selected this model because of the superior AIC performance and the overall confusion matrix value in comparison with the others.

In order to test the goodness of choice, we ran a Likelihood test (table 6.11). The results confirm that there is no significant difference between the set with the full specification and the set without logistic variables.

Table 6.11 Likelihood-ratio test - Darenchigre

Model	χ²	DF	p-value	
1 - 2	34.689	- 17.417	0.0068	**
1 - 3	4.689	- 4.663	0.455	ns
1 - 4	2.6508	1.478	0.1035	ns
1 - 5	62.289	- 18.527	1.672e-06	***
1 - 6	25.085	- 12.613	0.0225	*
1 - (3-4)	26.112	- 18.529	0.1271	ns

Signif. codes: "***" 0.001; "**" 0.01; "*" 0.05

6.2.3. Estimation of the Average Treatment Effect (ATT)

The estimation of the ATT of training and the general activities of the PC on the outcome variables Number of Chicken and Household Dietary Diversity score was elaborated with R (Team R Core 2018), using the following packages: diplyr (Hadley et al. 2018), tidyverse (Hadley 2017) and Matching (Sekhon 2011). Variables matching are presented in table 6.12 and 6.13.

Table 6.12 Head of Household and Spouse variables before and after balancing for both Beneficiaries (B) and Non-Beneficiaries (NB) using GenMatch - Darenchigre

variables		before	after	variables		before	after
Head of Household				*Spouse*			
Age	B	42.81	42.81				
(n°)	NB	42.74	43.63				
	St md	0.67	- 8.77				
	P val	0.9662	0.5653				
Employment	B	96.34	96.34	Employment	B	48.78	48.78
(%)	NB	81.25	97.56	(%)	NB	47.32	48.78
	St md	79.89	-6.46		St md	2.90	0
	P val	0.0005	0.3173		P val	0.8418	1
Employment in agriculture	B	65.85	65.85	Employment in agriculture	B	34.15	34.15
(%)	NB	40.18	67.07	(%)	NB	28.57	32.92
	St md	53.81	-2.56		St md	11.69	2.56
	P val	0.0003	0.5645		P val	0.4130	0.7396
Education	B	2.68	2.68	Education	B	2.32	2.32
(n°)	NB	3.25	2.56	(n°)	NB	3.05	2.24
	St md	-38.28	8.23		St md	-58.75	7.01
	P val	0.0213	0.3733		P val	0.0008	0.4779

Table 6.13 Household variables before and after balancing for both Beneficiaries (B) and Non-Beneficiaries (NB) using GenMatch - Darenchigre

variables		before	after	variables		before	after
Household							
Size	B	5.73	5.73	Distance from PC	B	2.24	2.24
(n°)	NB	5.08	5.51	(km)	NB	2.34	2.12
	St md	34.30	11.56		St md	-5.37	8.00
	P val	0.0172	0.4138		P val	0.7238	0.3811
Male/female ratio	B	1.05	1.05	Owner of bicycle	B	67.07	67.07
(n°)	NB	1.16	1.07	(%)	NB	55.36	65.85
	St md	-14.80	-2.65		St md	24.78	2.58
	P val	0.3449	0.7473		P val	0.0977	0.8662
Number of workers	B	2.67	2.67	Owner of motocycle	B	10.99	10.99
(n°)	NB	2.55	2.60	(%)	NB	25.00	15.85
	St md	9.79	6.11		St md	-44.59	-15.51
	P val	0.4891	0.4672		P val	0.0099	0.3714
Income	B	56,930	56,930	Rice cultivation	B	73.17	73.17
(Indian rupees)	NB	105,631	53,758	(%)	NB	41.07	73.17
	St md	-139.41	9.08		St md	72.00	0
	P val	0.0004	0.5022		P val	4.4478e-06	1
Agriculture as first source of income	B	29.27	29.27	Land rice size	B	0.44	0.44
(%)	NB	21.43	28.05	(ha)	NB	0.59	0.41
	St md	17.13	2.66		St md	-23.88	5.78
	P val	0.2210	0.6555		P val	0.0888	0.4978
Coordinator know the family	B	100	100	Number of cash crops	B	2.14	2.14
(%)	NB	86.60	96.34	(n°)	NB	2.40	2.39
	St md	Inf.	Inf.		St md	-27.83	-26.57
	P val	6.7147e-05	0.0814		P val	0.0782	0.0414
Toilet med	B	93.90	93.90	Livestock unit	B	1.95	1.95
(%)	NB	49.11	92.68	(n°)	NB	1.25	1.95
	St md	186.06	5.07		St md	56.77	0.11
	P val	4.7073e-14	0.3173		P val	0.0002	0.9936
Toilet bad	B	4.88	4.88				
(%)	NB	8.04	4.88				
	St md	-14.57	0				
	P val	0.3707	1				

We tested different NN settings (from 1 to 5, with Caliper equals 0.25 and 0.5) and GenMatch. The best balancing was obtained in both cases by using the GenMatch analysis. Matching quality results are presented in tables 6.14 (for the number of chicken) and 6.15 (for HDDs).

Table 6.14 Sensitivity analysis for Number of Chicken - Darenchigre

Matching Estimator	Balancing test [a]	N° of Observation matched	ATT estimated	p-value
Nearest neighbour 1	18	82	5.48	0.1836
Nearest neighbour 2	19	82	1.99	0.5812
Nearest neighbour 3	16	82	1.98	0.5504
Nearest neighbour 4	21	82	2.02	0.5074
Nearest neighbour 5	20	82	2.96	0.3170
Caliper (0.25)	16	75	5.06	0.1416
Caliper (0.50)	16	82	5.48	0.1836
NN 5 (Caliper 0.25)	20	57	5.31	0.0113
NN 5 (Caliper 0.50)	21	68	3.98	0.0987
GenMatch	21	82	1.43	0.5736

[a] number of explanatory variables with no statistically significant mean difference between the matched groups of the adopter and non-adopter households after matching.

Table 6.15 Sensitivity analysis for HDDs - Darenchigre

Matching Estimator	Balancing test [a]	N° of Obs matched	ATT estimated	p-value
Nearest neighbour 1	14	82	- 0.35	0.4693
Nearest neighbour 2	12	82	- 0.54	0.1436
Nearest neighbour 3	16	82	- 0.48	0.1487
Nearest neighbour 4	14	82	- 0.51	0.1195
Nearest neighbour 5	16	82	- 0.60	0.0476
Caliper (0.25)	17	64	- 0.40	0.1740
Caliper (0.50)	14	82	- 0.35	0.4693
NN 5 (Caliper 0.25)	20	48	- 0.39	0.0137
NN 5 (Caliper 0.50)	18	61	- 0.51	0.0151
GenMatch	22	82	- 0.33	0.2343

[a] number of explanatory variables with no statistically significant mean difference between the matched groups of the adopter and non-adopter households after matching.

The ATT obtained for the Number of Chicken is positive in each analisys but not significant; meanwhile the value of HDDs is negative but not significant.

6.2.4. Discussion

This research is among the few studies that jointly ex-amines the effects of a project on nutrition education, farm production, and household dietary diversity in a developing country context (Murendo *et al.*, 2018). This discussion is divided into two paragraphs. In the first, we discuss the result in the number of chicken and the second one the impact on Dietary diversity score.

Animal Husbandry

According to the description of data, between B and NB, there are significant differences. This confirms what found by Bertoni et al. (2015). Being involved mainly in agriculture appears essential to participate in the project, and after all, the project was focused mostly on on-farm intervention. Livestock breeding appears necessary for both NB and B and focusing the training on poultry management seems the right choice. Even if it is not possible to say anything about the condition before the beginning of the intervention, among B the poultry breeding tends to increase in importance. The intervention intensity was however low, due mainly to the little number of chicks dispensed among B. Probably, a more substantial amount of chick could have highlighted a more significant impact of the project. The intensity of the intervention should, however, be carefully calibrated because the families are not yet in a position to increase the number of chickens raised. This relates above all to the low quantity of feeding present on the market or obtainable from self-production. This is a positive development, especially taking into account that historically in the North East of India, tribes were not used to breed animals like chicken, cattle, sheep or goats (Behera et al. 2016). So, the C3S project can play an essential role in improving chicken husbandry among Garo's families, as well as playing a decisive role in rural people's livelihoods.

Household Dietary Diversity

On the other hand, improvement in chicken husbandry does not mean *tout court* improvement in dietary diversity among Garo's families. The Garo's diet is quite similar to another diet in similar contexts. In facts, similar results on the consumption of eggs and dairy product were found in Haiti (Pauzé et al. 2016), and in Ghana for the consumption of starchy

food and animal protein (Galbete et al. 2017). However, an analysis conducted in other rural areas shows that to improve dietary diversity it is often necessary to add to the diet proteins of the animal source (Murendo *et al.*, 2018), which is the primary goal of the nutritional training proposed in this project. The lack of improvement in beneficiary households could be ascribed to the difference in income and the general good access to the market.

As presented in the descriptive analysis, NB shows a significative difference in average income compared to B and fewer people employed in agriculture among NB compared to B. This suggests that NB relay more on purchasing food from the market than on own production. That means having access to a wide range of food provided by the local market, therefore, a better HDD score, as also suggested by Koppmair *et al*. (2017). Meanwhile people that rely more on self-production had less chance to be in contact with different kind of foods.

The not significative could also be explained because of the short term of implementation and the early stage of the survey. Changing diet is a long process that involves not only the availability of food and access but also the consciousness of the importance of each component in the diet. However, it should be stressed that cross-sectional data collected in a single round have limitations when they are used to assess diets mainly because single-round data do not reflect seasonal variation in dietary patterns that can be very important in rural areas. (Koppmair *et al*. 2017).

Moreover, interventions that aim to improve production diversity and nutrition education increase are found significant in improving HDDs. Murendo *et al.*, (2018), in their interesting research in Zimbabwe, found that producing one additional crop or livestock species leads to a 3 and 4% increase in household and women dietary diversity. In the same research, they found an increase of household, women, and children dietary diversity by 3, 9 and 25%, respectively. Increasing crop diversity by one crop species is associated with only a 4 and 5% increase in the number of food groups consumed by the household and women, respectively (Murendo *et al.*, 2018). Hirvonen et al. have funded in Ethiopia that improvement in nutritional knowledge leads in improving od HDDs among children (Hirvonen et al. 2017).

According to Madzivhandila et al. (2016), improving the long-term nutritional status of a population requires a long time and is more complex to be measured because many other factors influence it (food production and use, more or less nutrition knowledge of mothers, level of education, seasonality, etc.). The same authors suggest, on the contrary, that in situations with increasing population and food needs, although absolute poverty within a period of near to 25 years has been reduced, the number of undernourished people raised.

However, further investigation, in different time of the year, can better spot variation and improvement in the diet.

Regarding the quality of matching analysis, the overall measures of covariates imbalance show a good quality of matching. In fact, before matching, it is possible to find several significant differences in all the covariate variables means; while, after matching, the balancing among means was obtained for all the covariates.

7. Analysis of C3S project in the Democratic Republic of Congo

According to the introduction chapter in which the research objective and hypothesis have been described, the purpose of this chapter is to test the hypothesis:

The project has been able to enhance the food security among smallholder families that are involved in the project in Kabinda, Lomami province, Democratic Republic of Congo.

To test the hypothesis, two assumptions need to be verified: i) the project C3S has interventions or strategies able to affect the food security level of smallholder families and ii) it is possible to collect sufficient information to describe the nutritional status, food production, foodstuff conservation, economic and social situation in Kabinda and evaluate the impact.

Therefore, this chapter is organised into three sections. Section 1 is the introduction, where it recalls the hypothesis, which has to be tested. Section 2 is a discussion on the first assumption in which the sub-hypothesis 1, 2, 3 are verified. The following third part focuses on the sub-hypothesis 5 test, namely food access (section three), where methodology, data, results and discussion will be presented.

7.1. Interventions and strategies of C3S project

As stated for India, households in the study area can attain food security from either domestic production (food availability, namely field, husbandry and fish production) or purchasing from the market (food access) or a combination of both (Nyariki et al., 2002). In this particular context; however, families rely more on the market for purchasing food. Thus, C3S project should design intervention that aims to improve household production and or the food access to assess an overall improvement of food security. On sustainability, according to the sustainable intensification frameworks suggested by FAO (FAO 2011b; OECD and FAO 2018) project C3S should take into account the concept of Sustainable Diet (FAO 2010) according which other than the three pillars of sustainability (economic, social and environmental).

Data for analysis were collected from internal reports, mission reports and informal interview with the project coordinator and managers, other than bibliographic research (Bertoni et al. 2015, 2016; Minardi et al. 2015; Ndereyimana et al. 2018).

Intervention is described according to the following aspects: object, target, approach and results (research or implementation on the field). In table 7.1, we summarise the intervention divided into food availability, accessibility and sustainability (environmental, social and economic) areas.

Table 7.1 Summary of project C3S interventions divided by focus: food availability, food access, sustainability

Area	Intervention	Object	Target	Approach	Phase
F. Availability					
	Plant production				
	Cassava production	Improving Cassava yield	Farmers	Plot demo	On the field
	Vegetable Garden	Improving VG	Women	Plot demo	On the field
	Fruits trees	Trees Management	Households	Plot demo	On the field
	Composting	Fertilisation	Farmers	Trials	Research
	Animal Husbandry				
	Poultry breeding	Meat and egg production	Farmers	Training	On the field
	Storage	Reduction of losses	Households	Trials	Research
	Water sanitation	Improving the quality of water	Women, child	Trials	Research
F. Access					
	Diet diversity	Improving the quality of diet	Households	Training	On the filed
	Food				
	Santé	Complimentary food	Children	Supply	On the field
	Ameliorate food	Improving diet diversity	Households	Trials	Research
Sustainability					
Environmental	Domestic fires	Reduce air pollution	Household	Trials	Research
Environmental	Open defecation	Reduce water pollution	Household	Enquiry	Research
Social	Farmers Club	Social cooperation	Women	Teamwork	On the field

7.1.1.Strategies to improve the availability of food

Intervention on plant production:

- Cassava cultivation. The object has been to run a comparative test among several cassava ecotypes under different management conditions. Local small farmers were the target. The approach was demonstrative, planting the cassava ecotype in plot closer to traditional variety and methods. Nowadays, the PC is sharing the acquired knowledge with local farmers. According to the report, the initiative was positive; as a result, this intervention was implemented in the field, but nowadays it is not possible to get any sufficient data for further analysis;

- Vegetable garden: The object has been to introduce new ecotype of traditional foodstuff, i.e. sweet potato, such as notably the introduction of orange flash one to supply vitamin A in substitution of the white flash. Women, that usually take care of the small vegetable garden of the family are the target. Nowadays, the PC is sharing the acquired knowledge with local farmers;

- Fruit trees: The object of the intervention has been to provide fruit trees to households (target). The team are spreading seedlings of moringa, acacia, palm oil, avocado and mango, and more recently coffee. These trees are also planted in the area surrounding the pilot centre, creating an orchard to demonstrate the proper management of the trees.

- Composting: due to the abysmal percentage of organic matter in the soil, and the consequent low soil fertility, PC started trials to find a replicable methodology to produce compost at household level (target). Nowadays this intervention is in the research phase;

Intervention on Animal Husbandry

- Breeding of poultry. PC has provided ducks, turkeys, and laying hens chicklets to local farmers as well as technical assistance and training. The PC has purchased vaccinated chicklets from closer cities (but imported from Belgium), which would be an impossible thing for small farmers. According to the report, the initiative was positive; as a result, this intervention was implemented in the field, but nowadays it is not possible to get any sufficient data for further evaluation;

Intervention on Storage

- Losses (both quality and quantity) due to inefficient storage methods (insects and rodents) are common among the household. The first intervention, suggested by the local PC team, aimed to build metal silos using corrugated sheets by local blacksmith. These silos were built according to guidelines of FAO (2008). However, due to the not easier techniques and the costs, a new type of plastic bags was tested. The bag has multilayer plastic sheets that inhibit the oxygen passage into the bag and isolate the scent of grains or pulses. This double action contrast insects that cannot survive in anaerobically environment as well as rodents avoiding their attraction to the bag's content. Nowadays the intervention is on the research stage. Another advantage of bags is the possibility to reuse.

Water Sanitation

- The intervention aims to get safe water for human consumption (drinking and cooking). Targets are women and children. PC team is approaching the slow sand filters construction, starting from the construction to the tuning. These filters are easy to handle and not expensive to set up. Nowadays, the intervention is at research stage.

7.1.2.Strategies to improve access to food

Intervention on Improving nutrition

- Diet diversity: PC has promoted awareness programs focused on the importance of proteins, proper management of child feeding and a diversified diet. The target is the entire household, but especially the women that prepare the food for the family. Nowadays the intervention is in the implementation stage, also through broadcasting from the local diocesan radio station;

- Santé: PC has developed, with the help of the Italian team, a mixture of protein meals with local ingredients (corn, peanuts and soybeans toasted) as a complementary food of breast milk after three months (when mothers return to work after the delivery). The targets are both mothers and babies, but it is also utilised for convalescent people; its efficacy has suggested the name of Santé. The Santé is prepared by the PC and sold to families together elementary childcare information, especially on proper feeding;

- Ameliorate food. Usually, adult people in the area of Kabinda shows lack protein food consumption, as well as fresh vegetables. Then, PC has proposed to ameliorate a local recipe named "fufu" adding groundnuts to the usual starchy ingredient (cassava, or maize). Another suggestion is related to the deficiency of fresh vegetable consumption. Because the pitiable hygienic condition, it is not advisable to consume fresh vegetable. The cooking, otherwise, means losing thermolabile components of food. Thus, PC are trying to grill the vegetables (sanitising the surface and reducing the thermic expositions). Nowadays the intervention is at research stage;

7.1.1.Sustainability strategies

Intervention on domestic fire

- The object of intervention is the reduction of pollution inside the household due to an increased efficiency' of a domestic fire. The advantages are multiple: reduction of illness related to smoke (i.e. eye irritation, respiratory diseases) improvement of the air inside

the household, reduction of wood as fuel (then lower deforestation). Both women and head of household are the targets. Two approaches pursued: diffusion of improved domestic fire trying to replace the three-stone fire and to test improved fire. In both cases, the results are in elaboration, but still at the research stage.

Intervention on open defecation

- Local team enquiry the status of toilet facilities available for household trough questionnaire, trying to understand the impact of open defecation (especially in shallow waters). The targets are households as a whole. Nowadays the intervention is at the research phase.

Intervention on Farmers Organization

- This intervention aims to strengthen the social cohesion among women and men that are employed in agriculture, providing support and sharing information. Women are approached through social meetings, teamwork, visiting on households and sharing activities, as jam preparation. Thus, the implementation is in the field.

On the light of results that have been obtained from the analysis of the intervention proposed by the project C3S in Democratic Republic of Congo, the hypothesis that the project has lines of actions that aims to improve food availability, food access and in a context of sustainability (environmental, social and economic) is confirmed. Even if sustainable interventions played a significant role in improving the quality of life of the households, their evaluation is outside the present research project. That decision was made due to the limitation of data collected, which they do not allow us to perform a robust scientific analysis. Therefore, in the next sub-chapter will be discussing only the evaluation of food availability and access made by the project.

7.2. Evaluation of the impact on smallholder farms Food Security

In this section, the analysis of the project's impact will be presented. To perform the analysis, we collect 83 questionnaires, sorted in 45 non-beneficiaries (NB) family and 38 Beneficiaries (B)

Food Availability

As discussed before, among interventions on food availability promoted by the C3S project, both on plant production (horticulture and cassava, as well as fruit trees) and animal production (poultry) can be mentioned (Bertoni et al. 2015). Unlike what happened for India, the quality and quantity of data collected during the survey in January and February 2018, were not sufficient to run a proper evaluation of the impact on food availability by the project. That is probably due to the nature of the intervention, which is taking time to be fully implemented because a long time is needed to show results, but also for the cautious behaviour of farmers in the adoption. Therefore, the comparison among beneficiaries and non-beneficiaries has not been performed.

So far, the purpose of this evaluation is to estimate the project impact of on the diet diversity.

Food Access

The intervention is based on organising training and conference on the importance of animal protein in the diet, as long as fresh fruits and vegetables. To test the impact on food security has been tested the project impact on food access; namely it was verified if the difference of means was positive and significant on Household Dietary Diversity Score (HDDs) in favour of beneficiaries B.

7.2.1. Variables Description

In this paragraph, the topics presented in general terms in chapter 5 (material and methods) are recalled and analysed in depth. More precisely, the variables chosen for the evaluation will be presented. The first sets of variables are the outcome variables, namely the Household Dietary Diversity Score. The second set is the variables chosen to perform the propensity score matching.

Data are collected from a questionnaire filled during January and February 2018 among Congolese people that are living close to Saint Pierre parish in Kabinda. In this paragraph both

socio-economic data and diet data will be presented. Enumerators interviewed 38 families defined as Beneficiaries (B), which are involved in the project, and 45 families defined as Non-beneficiaries (NB), which are the control group and therefore are not involved in the project.

Diet in Kabinda

To test the impact on food security of the project, an HDDs was estimated. The groups of foods consumed were used to calculate the HDDs in seven days recalled. In table 7.2 the consumption of each food group for B and NB are showed.

Table 7.2 12 HDDs categories consumed by the household beneficiaries and non-beneficiaries of C3S Kabinda

number	Food groups	Not Beneficiaries		Beneficiaries	
		N	%	N	%
1	Cereals	45	100	38	100
2	White roots and tuber	19	42.2	13	34.2
3	Vitamin A-rich vegetables and tubers	44	97.9	38	100
4	Dark green leafy vegetables	28	62.2	28	73.7
5	Other vegetables	28	62.2	18	47.4
6	Vitamin A rich fruits	11	24.4	9	23.7
7	Other fruits	11	24.4	9	23.7
8	Organ meats	na	na	na	na
9	Flesh meats	14	36.8	24	63.2
10	Eggs	6	13.3	6	15.8
11	Fish and seafood	14	31.1	7	18.4
12	Legumes, nuts and seeds	36	80.0	30	78.9
13	Milk and milk production	1	2.2	0	0
14	Oils and fats	45	93.3	38	100
15	Sweets	6	13.3	6	15.8
16	Spices, condiments and beverages	45	100	38	100

na= not available

Cereals and spices, condiments and beverage food groups are the only two groups consumed by the 100% of the family, followed by vitamin A-rich vegetables and tuber (as pumpkin and carrots) and oil and fats (red palm oil, which is also rich in vitamin A). Vegetables are commonly consumed as dark green leaf (62.2 % NB and 47.4% of B) or other vegetables (62.2% for NB and 47.4% for B). With concern to the protein sources, the most important are those supplied

by legumes, nuts and seeds (80% of NB and 78.9% for B), then meat (36.8 NB and 63.2% for B), fish (31.1% NB and 18.4 B %). Eggs and milk commonly are not consumed: eggs 13.3% NB and 15.8% B, milk 2.2% for NB and 0% for B. Shares related to fruits consumption are 24.4 for NB and 23.7 for B.

In table 7.3, families are ranked according to the HDD score computed. HDD score range from 4 (lowest) to 11 (highest). The distribution of frequencies appears similar for NB and B. For both NB and B the HDD score mode is 7. This value is consistent with other values obtained in Zimbabwe (Murendo et al. 2018). Only among NB there is some household that reported only three classes of food groups consumed during the previous week; meanwhile only one family among B has declared to consume 11 groups of food.

Table 7.3 Household ranking according to HDDs divided into beneficiaries and non-beneficiaries of C3S - Kabinda

HDD score	Not beneficiaries		Beneficiaries	
	N	%	N	%
4	3	6.7	0	0
5	3	6.7	5	13.2
6	7	15.6	7	18.4
7	14	31.1	14	36.8
8	5	11.1	4	10.5
9	6	13.2	4	10.5
10	7	15.6	3	7.9
11	0	0	1	2.7

It is also interesting to know which food groups are predominately consumed at different levels of the score. In table 7.4, food groups are classified to provide information on dietary patterns according to the food groups consumed by at least 50% of household in each tercile. This procedure is common since there are no universal cut-offs for HDDs categorising (Swindale and Ohri-Vachaspati 2005; Pauzé et al. 2016).

In the lowest tercile (0-6), the family's consumed cereals, white roots and tuber, oil and fats, vegetables, spices condiments and beverage. To move in the second tercile (7), families would introduce more protein sources, such as legumes and meat. The range of HDDs value is consistent with Murendo et al. (2018).

Table 7.4 Food groups consumed by ≥50% of the household by dietary diversity tercile - Kabinda

Low ≤ 6	Medium 7	High > 8
Cereals	Cereals	Cereals
White roots and tuber	White roots and tuber	White roots and tuber
Oils and fats	Oils and fats	Oils and fats
Vegetables	Vegetables	Vegetables
Spices, condiments and beverages	Spices, condiments and beverages	Spices, condiments and beverages
	Legumes, nuts and seeds	Legumes, nuts and seeds
	Flesh meats	Flesh meats
		Fish and seafood
		Fruits

In the highest (8-12) tercile, 50% of families had introduced another source of proteins, namely fish, and fruits. These results seem consistent with Bertoni et al. (2015).

However, according to previous surveys in other parts of DRC, more diversified diets were commonly related to a good income, allowing families to buy food at the market. Therefore, there are no substantial differences in diets occurred in the last four years.

Choice of variables for Estimating Propensity Score

To elaborate the propensity score matching it is necessary to identify the variables which i) allow the comparison between beneficiaries and non-beneficiaries, and ii) affect both participation in treatment and outcome simultaneously (Caliendo and Kopeing 2008). In this research, both theoretical and empirical sources were consulted. Mainly, the previous works that used matching to investigate rural development were reviewed, such as Shiferaw et al. (2014), Salazar et al. (2016), Asadullah & Ara (2016) and Wordofa & Sassi (2017). According to these considerations, we have included hypothetical variables used for adequately matching the households in table 7.5.

These variables are divided into sets:

-   Set "head of household" (HH), which is composed by: age reported in actual years, employment status (if HH has a sort of guaranteed income or an occasional job), employment in agriculture (if the HH is involved in agricultural) and level of education (if the HH attended no school, primary, secondary or more than secondary);

Table 7.5 Hypothetical explanatory variable used in the first step to estimate the participation into the C3S project and their expected outcomes - Kabinda.

Instruments	Description	Type
Dependent variables		
Participation in C3S project	Involved status: 0= not involved, 1=involved	Categorical (dummy)
Variables		
HH age	Age of household in years	Continuous
HH employment status	Employment status 0= not employed, 1= employed	Categorical (dummy)
HH employed in agriculture	Agricultural employment status 0= not employed, 1= employed	Categorical (dummy)
HH Education status	Level of education	Continuous
Spouse age	Age of household in years	Continuous
Spouse employment status	Employment status 0= not employed, 1= employed	Categorical (dummy)
Spouse employed in agriculture	Agricultural employment status 0= not employed, 1= employed	Categorical (dummy)
Spouse Education status	Level of education	Continuous
Household size	Numbers of household members	Continuous
Male/female ratio	The ratio of male and female members of the household	Continuous
The first source of income	Agricultural activities are the first source of income 0= no, 1= yes	Categorical (dummy)
Livestock Unit	Livestock unit owned by the household	Continuous
Possession of motorcycle	Possession of means of transport 0= no, 1=yes	Categorical (dummy)
Possession of bicycle	Possession of means of transport 0= no, 1=yes	Categorical (dummy)
Distance from Pilot Centre	Distance between household and Pilot Centre	Continuous

- Set "spouse", which includes, age reported in actual years, employment status (if HH has a sort of guaranteed income or an occasional job), employment in agriculture (if the HH is involved in agricultural) and level of education (if the HH attended no school, primary, secondary or more than secondary);

- Set "Household", which incorporate: family size (number of people that live in the same dwelling and share at least one meal per day), male/female ratio in the family;

- Set "wealth", which encompass agriculture as first source of income of the family (yes, no), Livestock Unit owned (number), possession means of transport namely if the family owns bicycle (yes, no) or motorcycle (yes, no) because was not possible to collect the

direct income, we opted to descried the wealthiness through the aggregation of these variables;

- Set "logistic", namely the distance between the dwelling of the household and Pilot Centre (in kilometres).

Then, because of the small number of observation, a Logit regression has been used, to identify the set of variables suitable for the participatory analysis. Then using GenMatch (Sekhon 2011), we have identified the Average Treatment Effect on the Treated (ATT).

7.2.2.Results

In table 7.6, the socio-economic characteristics of the families interviewed are summarised. Ages of Head of Household (HH) are quite similar between NB and B: 46.2 ± 13.8 and 46.4 ± 13.0. About employment, meaning that the HH has a sort of a guaranteed income, 95.6 % among NB has one of it, meanwhile this percentage grow up to 97.4 % among B. Very few HH, both B and NB are involved in agriculture as main activities: 8.9 % of NB are employed in agriculture compared with 10.5% of B. In suburban such as those of Kabinda, numerous households own a vegetable garden and plot (which traditionally belongs to the family heritage) usually, even if the primary income comes from other activities than agriculture.

Education level shows the same trend with little difference in the higher classes: 8.89 % of NB and 5.26% of N state to have attended no school, 6.67% NB and 5.26 % B attended primary school, 51.11 % of NB and 44.74 % of B attended few classes or completed the secondary school, while 33.33 % of NB and 44.74 % of B complete or attended post-secondary school. In this case, the B is more educated than NB.

As regard to the spouse, ages are quite similar 37.1 ± 11.1 for NB and 38.2 ± 12.4 for B. Some differences appear about the employment (66.7% NB and 78.9% B), as well as for the percentage of spouse employed in agricultural as major activity (18.4% B compared to 11.10 % NB). The shape of the education level of spouse follows the same path of HH but for the tertiary classes. Indeed, 11.11 % of NB and 5.26% of B state no school, 15.56% NB and 26.32% B attended primary school, 60.00 % of NB and 60.53% of B attended some classes or completed the secondary level, while 13.33 % of NB and 7.89 % of B attended post-secondary school.

Focusing on variables related to the household, B families and NB families has quite the same number of components, which is: 6.07 ± 2.64 for NB and 6.76 ± 3.23 B. Females are more numerous in both families. The ratio -0.31 ± 1.82 in NB families and -0.42 ± 2.07 for B families,

meaning that the female is more than males. In both NB and B roughly 15 % of the families stated agriculture as the first source of income.

Table 7.6 Descriptive statistics – the socioeconomic status of households - Kabinda

	Variables	Not Beneficiaries	SD	Beneficiaries	SD
Head of Household	Age (years)	46.2	13.8	46.4	13.0
	Employment (%)	95.6		97.4	
	Employed in agriculture (%)	8.9		10.5	
	Education (%)				
	No school	8.89		5.26	
	Primary	6.67		5.26	
	Secondary	51.11		44.74	
	Post-Secondary	33.33		44.74	
Spouse	Age (years)	37.1	11.1	38.2	12.4
	Employment (%)	66.7		78.9	
	Employed in agriculture (%)	11.10		18.4	
	Education (%)				
	No school	11.11		5.26	
	Primary	15.56		26.32	
	Secondary	60.00		60.53	
	Post-secondary	13.33		7.89	
Household	Size (number)	6.07	2.64	6.76	3.23
	Male/female ratio (number)	-0.31	1.82	-0.42	2.07
	Agricultural as the first source of income (%)	15.6		15.8	
	Livestock unit (number)				
	0	30		25	
	0.1 - 0.4	9		9	
	> 0.5	5		4	
	Possession of Bicycle and Motorcycle (%)				
	Bicycle	53.30		76.30	
	Motorcycle	28.90		55.30	
	Distance from Pilot Centre (km)	4.77	2.65	4.28	2.46
	Total interviewed	45		38	

Animal husbandry activity is not widespread among the interviewed that because the hunter mentality is still widespread and because animals need many cures, including the night shelter in the home.

So, when the breeding is present, the animals are generally poultry, goat, rabbit or guinea pigs. 30 NB families and 25 declared no animal, namely 0 LU, only 9 (both NB and B) own 0.1 to 0.4 LU, and only 5 of NB families and 4 of B families have more than 0.5 LU. In this research it has been utilised the coefficient proposed for Africa by FAO (2011), adding a conversion factor of 0.01 for rabbit and assuming 0.005 for guinea pigs.

Moving to possession of means of transportation, 53.30 % of NB and 76.30 % of B own a bicycle; meanwhile the possession of motorcycle is lower than bicycles: 28.90 % of NB compared with 55.30 % of B. In both cases, the beneficiaries household holds the majority of means of transportation.

The distance between the Pilot Centre to the dwelling is similar for both NB and B 4.77 ± 2.65 km for NB and 4.28 ± 2.46 km for B.

The propensity to participate in the project are shown in table 7.7. To estimate what set of variables used for the first stage, several models have been tested:
- full specification, which has all the variables discussed in table 7.2
- without household (namely: the size of family, ratio male/female)
- without variables related to the head of the household (namely: age, employment status, employed in agriculture, level of education);
- without variables related to the spouse (namely: age, employment status, employed in agriculture, level of education);
- without variables related to wealth indicator (namely: the first source of income, livestock unit, possession of bicycles and motorcycles)
- without variables related to a logistic indicator (distance between dwelling and PC);
- without both head of household and spouse.

Given all these organised variables, we performed a test to estimate the quality of the statistical model in order to identify the set of variables that fit better.

Table 7.7 Variable sets evaluation using AIC e confusion matrix - Kabinda

	Model	AIC	NB%	B%	TOT
1	Full specification	116.8	88	51	70
2	Without household	115.3	88	46	68
3	Without the head of household	111.3	85	46	66
4	Without spouse	112.9	85	51	69
5	Without wealth indicator	120.8	88	30	60
6	Without logistics	116.6	85	46	66
3-4	Without the head of Household and Spouse	105.6	85	46	66

The parameters utilised are the Akaike information criterion (AIC), which is an estimator of information losses and the confusion matrix. AIC is used to test the model capacity to classify accordingly participant and non-participants to the project. The results highlight that the model without a set of spouse variables is the best choice.

In order to test the choice' goodness, a Likelihood test was run (table 7.8). The results confirm that there is no significant difference between the set full specification and the set without spouse variable. Thus, this last set was used for the GenMatch test.

Table 7.8 Likelihood-ratio test - Kabinda

Model	χ^2	DF	p-value	
mod 1 – mod 2	2.458	2	0.2926	ns
mod 1 – mod 3	2.543	4	0.637	ns
mod 1 – mod 4	4.109	4	0.391	ns
mod 1 – mod 5	12.045	4	0.017	*
mod 1 – mod 6	1.813	1	0.178	ns
mod 1 – mod 3 e 4	4.771	8	0.782	ns

Signif. codes: "***"0.001; "**"0.01; "*" 0.05

The results of the matching are presented in table 7.9. As it is possible to note, even before the matching almost all the variables showed no statistical differences between NB and B. Among HH variables, all of them show no significant difference, and the st md remains the same, except for employment and employment in agriculture, which get slightly worse. As regards of Spouse variables, all the variables show improvement both on p-value and st md. Focusing on Household variables, size, distance from pilot centre, owner of bicycle, motorcycle and LU improved bot p-value and st md; meanwhile male/female ratio and agricultural as first sources of income do not ameliorate both p-val and st md, still maintaining a significant difference. ATT analysis was performed using GenMatch to quantify the impact of PC on dietary diversity for the beneficiary household. The results are presented in Table 6.10. Using GenMatch it was possible to balance all the 15 variables and matching all the observations. The ATT is 0.162 and show no significant impact (p-value: 0.7576).

Table 7.9 Variable balancing for HDDs matching for Beneficiaries (B) and Non-beneficiaries (NB) using GenMatch - Kabinda

variables		before	after	variables		before	after
Head of Household				*Spouse*			
Age	B	46.43	46.43	Age	B	38.19	38.19
	NB	45.30	45.30		NB	36.15	39.35
	St md	8.69	8.71		St md	16.49	- 9.40
	P val	0.7122	0.3814		P val	0.4411	0.3666
Employment	B	97.30	97.30	Employment	B	78.38	78.38
	NB	95	100		NB	65	83.78
	St md	13.97	- 16.44		St md	32.06	- 12.95
	P val	0.6043	0.3175		P val	0.1966	0.5656
Employment in agriculture	B	10.8	10.8	Employment in agriculture	B	18.9	18.9
	NB	10.0	13.5		NB	12.5	24.36
	St md	2.58	- 8.59		St md	16.16	- 13.61
	P val	0.9089	0.5656		P val	0.4476	0.5289
Education	B	4.91	4.91	Education	B	3.84	3.84
	NB	4.80	4.81		NB	4.18	4.00
	St md	9.00	8.18		St md	-25.90	- 12.46
	P val	0.6945	0.4511		P val	0.2627	0.3307

variables		before	after	variables		before	after
Household							
Size	B	6.76	6.76	Owner of bicycle	B	78.38	78.38
	NB	5.98	6.30		NB	52.50	83.78
	St md	23.91	14.05		St md	62.01	-12.95
	P val	0.2537	0.2770		P val	0.0164	0.3175
Male/female ratio	B	- 0.51	- 0.51	Owner of motorcycle	B	54.05	54.05
	NB	- 0.33	- 0.24		NB	27.50	48.65
	St md	- 9.32	- 13.36		St md	52.56	10.70
	P val	0.6607	0.2689		P val	0.0179	0.31745
Agriculture as first source of income	B	16.22	16.22	Livestock unit	B	0.18	0.18
	NB	15.00	13.51		NB	0.10	0.17
	St md	3.25	7.23		St md	18.78	0.71
	P val	0.8852	0.5656		P val	0.3107	0.9688
Distance from PC	B	4.21	4.21				
	NB	4.93	4.34				
	St md	- 29.40	- 5.50				
	P val	0.2223	0.6591				

Sensitivity analysis has been performed by Nearest Neighbour with replacement (NN = 1,2,3,4,5), Caliper (0.25; 0.5) and a combination of NN = 5 and Caliper (both 0.25 and 0.50) to check if GenMatch result is robust compared to other methods. In table 7.10, the results are shown.

Table 7.10 Sensitivity analysis for HDDs - Kabinda

Matching Estimator	Balancing test [a]	N° of Obs matched	ATT estimated	p-value
Nearest neighbour 1	15	37	0.081	0.8862
Nearest neighbour 2	15	37	0.378	0.5047
Nearest neighbour 3	14	37	0.234	0.6859
Nearest neighbour 4	15	37	0.203	0.7327
Nearest neighbour 5	15	37	0.108	0.8523
Caliper (0.25)	15	37	0.081	0.8862
Caliper (0.50)	15	37	0.081	0.8862
NN 5 (Caliper 0.25)	15	21	-0.743	0.0443
NN 5 (Caliper 0.50)	15	29	-0.448	0.3239
GenMatch	15	37	0.162	0.7576

[a] number of explanatory variables with no statistically significant mean difference between the matched groups of the adopter and non-adopter households after matching.

All the ATT estimate are quite similar in all the simulation, to the exception of those elaborated using NN plus Caliper, which show a negative ATT. In that case, the number of observations matched was only 21 and 29, respectively. Therefore, NN plus Caliper performed worse than another matching method. Thus, the results presented in Table 6.10 confirm that GenMatch is robust and performs well as other matching estimators.

7.2.3. Discussion

The diet is quite similar to other diets in similar contexts. Similar results on consumption of eggs and dairy product were found in Haiti (Pauzé et al. 2016). As presented in the descriptive analysis, in general NB show a significant difference compared to B. This suggests that even if some bias were present during the survey activity, they are weak, and however addressed by the matching. NB and B show different diet habits, especially on vegetable consumption and animal protein sources. NB consume more vegetable than B, and among B families the most important sources of animal proteins are meat, meanwhile for NB are both meat and fish

(roughly 30% of the families). Similar results on consumption of eggs and dairy product were found in Haiti (Pauzé et al. 2016). Consumption of starchy food and animal protein of beneficiaries are similar to those were found in Ghana (Galbete et al. 2017). The analysis shows that to improve dietary diversity, it is necessary to add to the diet animal source proteins and legumes, which is the primary goal of the project training. Both legumes and meat are valuable sources of income, and usually some low-income families prefer to sell these foodstuffs to gain money instead of improving their own diet variety. This behaviour is usually related of the ignorance of the real nutritional value of the food. ATT is not diverse between B and NB; however, this result was expected because of the short period of implementation of the intervention and the possibility of spill over.

Changing diet is a long process in which food availability and access, but nutrition knowledge is involved. However, it should be stressed that cross-sectional data collected in a single round have limitations. That can be very important in rural areas due to the seasonal variation in dietary patterns (Koppmair *et al*. 2017).

According to Madzivhandila et al. (2016) to improve a long-term nutritional status of a population requires a long time and is more complex to be measured because many other factors influence it (food production and use, more or less nutrition knowledge of mothers, level of education, seasonality, etc.). Still, interventions that aim to improve production diversity and nutrition education increase are found significant in improving HDDs.

From the point of view of production, Murendo *et al.*, (2018) found that producing one additional crop or livestock species leads to a 3 and 4% increase in household and women dietary diversity. Other authors suggest same conclusion (Malapit et al. 2015; Koppmair et al. 2017).

Similar findings are provided by Hirvonen et al. (2017) that also highlights how in case of good food access a further improvement in dietary diversity would came only from the improvement of family nutrition knowledge. Therefore, it would be the privileged approach.

In regard to the quality of matching analysis, the overall measures of covariates imbalance show a good quality of matching. That is true even if before the matching, almost all the variables shown no significant differences in all the covariate variables. However, further investigation, in different time of the year, can better spot variation and improvement in the diet.

8. General conclusion

Food Security

Food security is a challenge that has to be played on the ground of rural areas of developing countries. In fact, the most exposed people to food insecurity and poverty live in these areas, especially Sub-Saharan Africa and Southern Asia. They are small farmers, which cultivate less than two hectares in an agricultural subsistence regime. To escape that precarious condition, agricultural development is a crucial element. Through agriculture pathways, namely i) own production, ii) agricultural income and iii) family members involvement, it could be possible to trigger the whole rural development mechanism. Focusing on the first two pathways, it is also possible to improve food security. That is improving the quality of food derived by own production, namely the increase the nutrient-rich food crop production and production diversification (both plant and animal). Even if it is commonly accepted that agriculture can play an essential role in enhancing food security, the precise path of how agriculture may do this in some developing countries remains debatable.

In this research, we presented the intervention operated by the "Production of appropriate food: sufficient, safe and sustainable" project (also known as C3S) among rural population in Darenchigre, Meghalaya State (India) and in Kabinda (Lomami Province, DRC). The two hypotheses under investigation are connected to the C3S project abilities to design intervention on food security (namely food production and food access) and the related impact of such intervention on food security (both food production and access). To answer to those question we analyse the Number of Chicken as a food production proxy and HDDs as food access proxy.

C3S project

C3S project rely on several pillars. Subsidiarity and participation, which means developing actions and strategies to improve the livelihood of people in perspective to support the personal and community initiative. Another focus point is the holistic approach, to address different aspects of food insecurity, such as production (i.e. shortage of input, proper agricultural skills), access (i.e. low income, subsistence agriculture) and utilisation (i.e. shortage of valuable source of proteins in the diet, appropriate weaning). The third pillar is the scientific approach. That means that all the interventions proposed have a research background and have been validated through field experimentation, according to the principles of Sustainable Intensification and Sustainable Diets. The project aims to overcome

subsistence agriculture, to the gradual increase of land cultivated per family (family farms), as well as to enhance knowledge and tools to food production - even through the Self Helps Group. This research is a comprehensive and systematic analysis of both the context about household food security among the rural population and of the C3S project characteristics. Household food security concerns two main aspects: food availability (self-production) and access (of market origin). So far, the project aimed to design interventions to enhance food production, both animal and plant, as well as food access (aiming to improve the diet). This also implies an increase of non-farm income, in the framework of the participatory process. All the data were gathered through questionnaire survey activities and, then, elaborated with matching score techniques as Logit (nearest neighbour) and GenMatch. C3S project designed specific intervention on both production and access, obviously declined differently, according to the local context.

Darenchigre, Meghalaya State (India)

In India, enumerators interviewed 82 families Beneficiaries (B) and 112 Not Beneficiaries (NB). The head of the household shows some differences between B and NB. The average age is higher in NB (46.9 vs 41.4), while the agriculture employment in higher among B (61.2% vs 19.2%), as well as the first source of income as agricultural activity (12.8% of NB and 28.6% of B). Education level showed higher values among NB than B (no school is 40.8% vs 24.3 %). Similitudes appear on family size (roughly 5 members) and the average distance from the Pilot Centre (2.35 km). On the other hand, annual income has shown a significant difference (11,451 ± 12,384 for NB and 10,927 ± 8,811 Rupees). Moving to the land cultivated, roughly 80% of B and NB cultivated 0.1 to 0-8 ha of land.

Analysis of food production has been made evaluating the poultry training impact. Results showed that the Number of Chicken is greater in B compared to NB, although not statistically significant. Poultry is quite crucial among farmers in this area because they ensure the circular economy (by-product) and the utilisation of many natural resources (insects, worms, herbs), and the initiative was well welcomed. With regards to Household Dietary Diversity, used as an indicator of food access, the result showed no significant difference between B and NB. The value of HDDs was relatively high, but fruits, meat, eggs and milk are still missing, and, according to the dietary patterns, they could substantially improve the diet. Since it was demonstrated that changing the diet is more complicated than modifying productive

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methods, activating an educational path, focused on nutrition issues, is essential. Education remains an important pillar to promote rural development.

Kabinda, Lomami province (Democratic Republic of Congo - DRC)

In Kabinda, enumerators interviewed 38 families Beneficiaries (B) and 45 Not Beneficiaries (NB). The head of household show no differences between B and NB. The average age similar in NB (46.2 vs 46.4), as the agriculture employment in higher among B (8.9% vs 10.5%), meanwhile the first source of income as an agricultural activity in higher among B than NB (11.10% of NB and 18.4% of B). Education level showed similar values among NB than B (no school is 8.89% vs 5.26 %). Similitudes appear on family size (roughly 6 members) and the average distance from the Pilot Centre (average 4.5 km). Analysis of food production has not been made because of the poor quality and quantity of data, both concerning plant and animal production. This problem came out for several reasons. The most important are the following: first of all, the intervention on plant production regards only a few plots (vegetable garden), so collecting information was not easy.

Meanwhile, animal production interview did not produce enough data for reliable evaluation. So far, the project continues in training and supporting local farmers to increase the number of beneficiaries. With regards to Household Dietary Diversity, as an indicator of food access, the results showed no significant difference between B and NB. The analysis was performed both Logit and GenMatch. Legumes, meat, fish and fruits are barely consumed in the diet, while eggs and milk are not consumed. It is important to note that, since a large share of households declares as primary income sources something not related to agriculture, these households rely mostly on market supply. Especially, eggs, through better management of poultries, could become an interesting source of proteins for the family; but improved bred are needed (as for Kuroiler in India).

What emerged from the survey is linked to the territories examined. However, the project demonstrates that similar problems in similar contexts can be effectively addressed through the C3S approach and similar lines of action (but properly related to the context).

Study Limitation

Due to the particular context where the research took place, we were able to analyse a small sample. That could be a problem to generalise the finding for all the area under study. Other

two main limitation is related to the HDDS index. In this research, HDDs is collected only one time. Therefore, it is not possible to trach how the project influenced the food security long the all intervention period. The other limits of HDDs are linked to the absence of the quantity of food eaten, which does not allow a precise comparison among families. SUTVA assumption was well addressed concerning the treatment definition, while it is not easy to exclude spillover effect among families, especially for India. The spillover effect is desirable and aligned to the purpose of the project in both cases. However, it does not allow the research to state clearly whether the no statistical differences in the outcome is due to the treatment inefficacy. Nevertheless, the intensity of intervention was low due to the development context in which the project operated and to appreciate some variation still require extended time.

Further recommendation

As final remarks, new research on the project should cover other aspects, such as economic efficiency in the long term or its replicability in another context (closer to the Pilot Centre or in other countries). For the statistical approach, it is advisable to adopt a difference-in-difference technique. This technique aims to compare the average change over time in the outcome variable for the treatment group, compared to the average change over time for the control group. This would allow evaluating the project progresses through the years. Focusing on the indices for assessing food security, shifting from HDDs to FCS and the FIES could improve the analysis on food security impact, due to the more in-depth evaluation allowed by these two indices. Another essential aspect which should be addressed in the project evaluation would be the Sustainability Evaluation. This evaluation should analyse not only the economic point of view but also considering the environmental and social implication of this development proposal. Moving to the internal project organisation, a better internal report activity may facilitate project progress.

Acknowledgements

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Annex 1 Questionnaire

DEAR MISTER/MISS,

I AM (<u>NAME OF ENUMERATOR</u>) AND I WORK FOR THE *AGRICULTURAL CUM NUTRITIONAL PROJECT*, AT ST' ALPHONSA CHURCH PARISH IN DARENCHIGRE. THE AIMS OF THIS QUESTIONNAIRE IS TO INVESTIGATE THE FOOD SECURITY LEVEL IN THE AREA SURROUNDING OUR CHURCH.

I WOULD LIKE TO ASK THE QUESTIONS IN THIS FORM TO YOU AS HEAD OF HOUSEHOLD. I WILL ALSO NEED TO ASK QUESTIONS TO OTHER MEMBERS OF YOUR HOUSEHOLD. THESE QUESTIONS WILL TAKE "**A COUPLE OF HOURS**" TO BE COMPLETE. ALL OF YOUR ANSWERS WILL BE HELD IN CONFIDENCE. THE ANSWERS WHICH YOU AND THE MEMBERS OF YOUR HOUSEHOLD MIGHT GIVE ME WILL ONLY BE USED BY THE *AGRICULTURAL CUM NUTRITIONAL PROJECT* AND FOR SCIENTIFIC RESEARCH BY THE MEMBER OF THE TEAM.

BEFORE I START, DO YOU HAVE ANY QUESTIONS, OR WOULD YOU LIKE ANY FURTHER CLARIFICATION?

MAY I PROCEED WHIT INTERVIEWING YOU AND MEMBERS OF YOUR HOUSEHOLD?

QUESTIONS

GENERAL QUESTIONNAIRE

9. HOUSEHOLD MEMBER LIST

☐ 1.1 NAME OF FAMILY MEMBERS

in line 1 write the head othe f house and then the other members othe f house. make a complete list of all individuals who normally live and eat their meals together in this household.

☐ 1.2 ONLY FOR THE NEW BORN

sex, relationship to the head of household

☐ 1.3 WHAT HAS (NAME) MAIN OCCUPATION BEEN FOR THE PAST 12 MONTHS?

1 … agriculture/livestock; 2 … fishing; 3 … mining; 4 … tourism;
<u>employed not in agriculture</u>: 5 … government; 6 … parastatal; 7 … private sector; 8 … NGO's/religious;
9 … with employees; 10 … without employees; 11 … unpaid family work; 12 … job seeker; 13 … student;
14 … disabled; 15 … no job; 16 … too young, 17 … retirement, 99 … don't know;

10. EDUCATION

☐ 2.1 IS (NAME) CURRENTLY **AT SCHOOL**?

1 … yes; 2 … no

☐ 2.2 HOW MANY YEARS OF SCHOOL DID/DOES/(NAME) HAS ATTENDED

1 … no school; 2 … some primary; 3 … completed primary; 4 … some secondary; 5 … completed secondary;
6 … more than secondary; 7 … don't know

11. HEALTH

☐ 3.1 HAS (NAME) HAD (DISEASE) IN THE LAST MONTH?

1 … yes; blank … no

ONLY FOR DIARRHEAL

☐ 3.2 NOW, I WOULD LIKE TO KNOW, USUALLY, HOW MUCH (NAME) WATER HAD DRUNK DURING THE DIARRHEAL.

1 … much less; 2 … somewhat less; 3 … about the same; 4 … more; 5 … nothing to drink; 6 … don't know

☐ 3.3 WHAT KIND OF BEVERAGE HAS HE/SHE DRANK?

☐ 3.4 HAS HE/SHE EAT, ABOUT THE SAME AMOUNT, OR MORE THAN USUAL TO EAT?

1 … much less; 2 … somewhat less; 3 … about the same; 4 … more; 5 … nothing to eat; 6 … don't know

☐ 3.5 WHAT KIND OF FOOD HAD HE/SHE EAT?

1 … yes; 2 … no

☐ 3.6 DID YOU SEEK ADVICE OR TREATMENT?

advice from: 2 … assistance from village health service; 3 … assistance from agricultural cum nutritional project; 4 … vermicide; 5 … antibiotic traditional methods (which one?); 6 … head of the village; 7 … grandmother; 8 … other

CHILDREN <5 YEARS

☐ 3.7 FOR HOW LONG WAS (NAME) EXCLUSIVELY BREASTFED?

write "98" if the mother is dead; months

☐ 3.8 HOW MANY TIMES DID (NAME) RECEIVE … YESTERDAY?

numbers

☐ 3.9 WHAT KIND OF COMPLEMENTARY FOOD BESIDES BREASTFEEDING (NAME) HAS EATEN?

1 … yes; 2 … no   If cd.po please write which one

☐ 3.10 WHEN DID (NAME) STARTED TO EAT THE SAME FOOD THE FAMILY DOES?

(months)

12. LABOUR

INTRODUCTION

☐ 4.1 ONLY FOR ENUMERATOR: IS THE HOUSEHOLD MEMBER 5 YEARS OR ABOVE?

1 … yes; 2 … no

☐ 4.2 ONLY FOR ENUMERATOR: IS THE PERSON ANSWERING FOR HIMSELF/HERSELF

1 … yes; 2 … no

☐ 4.3 DID (NAME) DO ANY WORK FOR ANY TYPE OF PAY, PROFIT, BARTER OR HOME (NOT HOUSEWORK) USE DURING THE LAST 7 DAYS IN 2017?

1 … yes (go wage job or self-employment section); 2 … no (go head)

☐ 4.4 ALTHOUGH (NAME) DID NOT WORK DURING THE LAST 7 DAYS, DOES HE/SHE HAVE A JOB OR OWN FARM OR ENTERPRISE AT WHICH HE/SHE HAS NOT WORKED DURING THE LAST 7 DAYS AND AT WHICH HE/SHE WILL RETURN TO WORK IN 2017?

1 … yes (go wage job or self-employment section); 2 … no (go unemployment section)

☐ 4.5 WHY WAS (NAME) NOT AVAILABLE FOR OCCASIONAL WORK?

Reason

☐ 4.6 WHY WAS (NAME) NOT AVAILABLE FOR CONTINUOUS WORK?

Reason

☐ 4.7 HAS (NAME) TAKEN ANY STEPS TO LOOK FOR A WORK?

1 … yes; 2 … no

☐ 4.8 WHEN WAS THE LAST TIME (NAME) DID WORK FOR PAY, PROFIT OR GAIN (IF ANY)?

months

AFTER FILLED THE YEARS 2017 PLEASE FILLED THE YEAR 2016 REFERRING AT ALL 2016 YEAR

GO TO GENERAL SECTION

WAGE JOB

☐ 4.12 IS (NAME)'S EMPLOYER FOR THIS WORK:

*1 … central gov.; 2 … local gov.; 4 … cooperative; 5 … NGO's; 6 … int'l org; 7 … political party;
8 …. religious org; 9 … private sector; 10 …*

☐ 4.13 WHAT KINDS OF TRADE OR BUSINESS IS IT CONNECTED WITH?

☐ 4.14 DOES (NAME) RECEIVE WAGES, SALARY OR OTHER PAYMENTS EITHER IN CASH OR IN OTHER FORMS FROM THIS EMPLOYER FOR THIS WORK?

1 … yes; 2 … no (go to 4.16 and skip 4.15 e 4.17)

☐ 4.15 HAVE YOU RECEIVE ANY THINGS FOR THIS WORK?

1 … food; 2 … service; 3 … work tools; 4 … other tools (go to 4.16 and skip 4.15 e 4.17)

☐ 4.16 **ONLY IF DON'T RECEIVE ANY PAYMENT:** WHAT WAS THE MAIN REASON (NAME) DID NOT RECEIVE ANY PAYMENT FOR THIS WORK?

1 … apprenticeship or unpaid traineeship; 2 … labour paying off debt; 3 … other (specify)

☐ 4.17 HOW OFTEN (NAME) IS PAID AND HOW MUCH?

time unit: 1 … day; 2 … week; 3 … month; 4 … quarter; 5 … half year; 6 … year

☐ 4.18 HOW MANY HOURS DID (NAME) WORK LAST WEEK?

hours

☐ 4.19 DID (NAME) RECEIVE ANY PAYMENT FOR THIS WORK IN ANY OTHER FORM?

apart from salary: 1 … yes; 2 … no

AFTER FILLED THE YEARS 2017 PLEASE FILLED THE YEAR 2016 REFERRING AT ALL 2016 YEAR

SELF-EMPLOYMENT

☐ 4.20 DID (NAME) OPERATE ANY BUSINESS OR DID ANY SELF-EMPLOYED ACTIVITY, OTHER THAN AGRICULTURE?

1 … yes; 2 … no

☐ 4.21 WHAT KIND OF BUSINESS DOES (NAME) OPERATE?

if you don't know, put "9999"

☐ 4.22 WHERE DOES (NAME) DO BUSINESS?

1 … home; 2 … structure attached to/outside house; 3 … fixed stall/kiosk – in market; 4 … vehicle, cart, temp. stall – in market; 5 … fixed stall/kiosk – in street; 6 … vehicle, cart, temp. stall – in street; 7 … other temp. structure; 8 … construction site; 9 … client's/employer's house; 10 … no fixed location/mobile

☐ 4.23 HOW LONG HAS THIS BUSINESS BEEN EXISTING?

years; if < 1 years write "0"

☐ 4.24 WHAT WAS THE MOST IMPORTANT SOURCE OF START-UP CAPITAL FOR THIS INCOME GENERATING ACTIVITY?

1 … loan from family/friends.; 2 … gift from family/friends.; 3 … sale of assets owned; 4 … proceeds from another business; 5 … own savings; 6 … loan from self-help groups; 7 … non-agricultural credit; 8 … bank or other institution; 9 … loan from money lander; 10 … inherited; 11 … agricultural cum nutritional project; 12 … other (specify)

☐ 4.25 TO WHOM DOES (NAME) SELL MOST OF HIS/HER PRODUCTS OR SERVICES?

1 … final consumer; 2 … small business; 3 … large established business; 4 … institutions; 5 … export; 6 … manufacturers; 7 … government; 8 … other (specify)

☐ 4.26 WHAT WAS (NAME) AVERAGE NET INCOME (PROFIT) DURING THE MONTHS WHEN YOU OPERATED THIS BUSINESS?

rupees

☐ 4.27 DID (NAME) OPERATE OTHER BUSINESS OR DO ANY OTHER EMPLOYS ACTIVITY DURING THE LAST 12 MONTHS, OTHER THAN AGRICULTURE?

1 … yes; 2 … no

AFTER FILLED THE YEARS 2017 PLEASE FILLED THE YEAR 2016 REFERRING AT ALL 2016 YEAR

GENERAL

☐ 4.28 IN THE LAST 7 DAYS, HOW MANY HOURS DID (NAME) WORK AS AN UNPAID FAMILY WORKER ON A NON-FARM HOUSEHOLD BUSINESS?

hours

☐ 4.29 IN THE LAST 7 DAYS, HOW MANY HOURS DID (NAME) SPEND ON HOUSEHOLD AGRICULTURAL ACTIVITIES (INCLUDING LIVESTOCK OR FISHING, WHETHER FOR SALE OR FOR HOUSEHOLD FOOD)

hours

☐ 4.30 HOW MANY MINUTES DID YOU SPEND YESTERDAY COLLECTING FIREWOOD (OR OTHER FUEL MATERIALS)?

minutes

☐ 4.31 HOW MANY MINUTES DID YOU SPEND YESTERDAY COLLECTING FETCHING WATER?

minutes

☐ 4.32 HOW MANY MINUTES DID YOU SPEND YESTERDAY COOKING AND HOUSE WORKING?

minutes

13.CREDIT, HOUSING AND WATER SANITATION

☐ 5.1 WHICH IS THE HOUSEHOLD MAIN TWO SOURCES OF CASH INCOME?

(write the two most important income sources): 1 … sale of food crops; 2 … sale of livestock; 3 … sale of livestock products; 4 … sale of cash crops; 9 … sale of fish; 5 … business income; 6 … wages or salaries in cash (continues job); 7 … other casual cash earnings (casual job); 8 … cash remittance (payment); 10 … pension, 11 … other

☐ 5.2 OVER THE PAST 12 MONTHS, DID YOU OR ANYONE ELSE IN THIS HOUSEHOLD BORROW FROM SOMEONE OUTSIDE THE HOUSEHOLD OR FORM AN INSTITUTION RECEIVING EITHER CASH, GOODS, OR SERVICES?

include loans for agriculture. probe for goods or services received on credit;

☐ 5.3 WHAT ARE THE NAMES OF THE PERSONS OR INSTITUTIONS FROM WHOM YOU OR ANYONE ELSE IN YOUR HOUSEHOLD BORROWED OR TOOK CREDIT?

1 … commercial banks; 2 … micro-finance inst.; 3 … building soc./mortgage; 4 … insurance companies;
5 … other financial inst.; 6 … neighbours/friends; 7 … grocery/local merchant; 8 … money lender; 9 … employer; 10 … religious inst.; 11 … NGO; 12 … self-help group; 13 … other

☐ 5.4 WAS THIS A CASH LOAN OR GOODS ON CREDIT?

1 … cash; 2 … goods

☐ 5.5 WHAT DID YOU USE THIS LOAN/CREDIT FOR?

1 … Subsistence needs; 2 … Medical cost; 3 … School fees; 4 … Ceremony/Wedding; 5 … Purchase land; 6 … Purchase agric. Inputs; 7 … Other business inputs; 8 … Purchase agric. Machinery; 9 … Buy/build dwelling; 10 … Other(Specify); 99 … No reason

☐ 5.6 WHAT IS THE HOUSEHOLD'S MAIN SOURCES OF DRINKING WATER IN THE (SEASON)?

1 … piped water inside dwelling; 2 … private outside standpipe/tap; 3 … public standpipe/tap; 4 … neighbouring household; 5 … water seller; 6 … water track/tanker service; 7 … well with pump; 8 … well without pump; 9 … river, lake, spring, pond; 10 … rainwater; 11 … other; 12 … open well; 13 … covered well

☐ 5.7 WHAT MEASURES DOES THIS HOUSEHOLD TAKE TO ENSURE THE SAFETY OF DRINKING WATER?

1 … boiling water; 2 … solarisations; 3 … bottled water 4 … none; 5 … filtered; 6 … chemical treatment;

14.ASSISTANCE AND GROUPS

☐ 6.1 DID YOU OR MEMBERS OF YOUR HOUSEHOLD ATTEND ANY PROGRAM (…) IN THE PAST 12 MONTHS?

☐ 6.2 IS ANYONE IN THE HOUSEHOLD INVOLVED BENEFICIARIES IN AGRICULTURAL CUM NUTRITIONAL PROJECT?

1 … yes; BLANK … no

15.RECENT SHOCKS TO HOUSEHOLD WELFARE

☐ 7.1 OVER THE PAST YEARS (2017), WAS YOUR HOUSEHOLD SEVERELY AFFECTED NEGATIVELY BY ANY OF THE FOLLOWING EVENTS?

***a**: 1 … yes; BLANK … no;   **b**: 1 … most severe; 2 … second severe; 3 … third severe*

THE QUESTIONS TO THE RIGHT SHOULD ONLY BE ASKED CONCERNING THE THREE MOST SEVERE SHOCK, AS NOTED IN QUESTION 2. LEAVE ALL OTHER ROWS BLANK.

☐ 7.2 DID (SHOCK) CAUSE A REDUCTION IN HOUSEHOLD INCOME AND OR ASSETS?

1 … income loss; 2 … assets loss; 3 … both; 4 … neither

☐ 7.3 HOW DISPERSE WAS THIS SHOCK? IT AFFECTED:

1 … only this household; 2 … some other household; 3 … most household in this community; 4 … all household in this community

☐ 7.4 WHEN DID THIS SHOCK OCCURS?

number

16.FOOD CONSUMPTION OUTSIDE THE HOUSE

THE QUESTIONS 1 TO 8 HAVE TO BE ASKED FOR ALL THE MEMBER OF HOUSEHOLD (EXCLUDED SCHOOL MEALS)

☐ 8.1 DID (NAME) CONSUME ANY MEAL/SNACKS/ DRINK OUTSIDE THE HOUSEHOLD IN THE PAST 7 DAYS?

1 … yes; 2 … no

☐ 8.2 HOW OFTEN DOES (NAME) EAT OUTSIDE THE HOUSEHOLD DURING A WEEK?

number

☐ 8.3 ON AVERAGE HOW MUCH DOES (NAME) SPEND TO EAT OUTSIDE PER WEEK?

rupees

☐ 8.4 WHY DID (NAME) EAT OUTSIDE THE HOUSEHOLD?

1 … working far; 2 …. likes it more; 3 … it's easy; 4 … it's fast; 5 … it's cheap

☐ 8.5 WHERE DID (NAME) CONSUMED HIS LAST FULL MEAL OUTSIDE THE HOUSEHOLD?

1 … stable kiosk; 2… street; 3 … mobile stall; 4 … restaurant; 5 … fast food

☐ 8.6 WHAT DID YOU EAT?

1 … samosa; 2 … mixed snacks; 3 … dry fruits and legumes; 4 … areca-nut and battle leaves; 5 … soft drinks; 6 … other (write aside what); 7 … chips

☐ 8.7 DOES (NAME) USUALLY CHOOSE THE SAME PLACES TO EAT OUTSIDE THE HOUSEHOLD?

1 … yes; 2 … no

☐ 8.8 IF SO, WHY DOES (NAME) USUALLY CHOOSE THE SAME PLACE?

1 … credit; 2 … it is good; 3 … he/she knows him;4 … it is clean; 5 … the food is cheap; 6 … other

17.FOOD CONSUMPTION OVER PAST ONE WEEK

☐ 9.1 WITHIN THE PAST 7 DAYS, DID THE MEMBERS OF THIS HOUSEHOLD EAT/DRINK ANY (…) WITHIN THE HOUSEHOLD?

☐ 9.2 HOW MUCH IN TOTAL DID YOUR HOUSEHOLD CONSUME IN THE PAST 7 DAYS?

☐9.3 HOW MUCH CAME FROM PURCHASE DURING THE PAST 7 DAYS?

☐9.4 HOW MUCH DID YOU SPEND?

☐9.5 HOW MUCH CAME FROM OWN-PRODUCTION?

☐9.6 HOW MUCH CAME FROM GIFTS AND OTHER SOURCES?

☐9.7 IN THE LAST 7 DAYS DID ANYBODY THAT YOU DID NOT LIST AS HOUSEHOLD MEMBERS EAT ANY MEALS IN YOUR HOUSEHOLD?

☐9.8 IN THE LAST 7 DAYS ANY CHILDREN EAT MEALS AT SCHOOL OR AT BOARDING SCHOOL?

18.HOUSEHOLD MEMBER ROSTER

☐ 10.1 DID YOU OR ANYONE IN THIS HOUSEHOLD OWN OR CULTIVATE ANY PLOTS DURING **THE LAST YEAR (2017)**?

☐ 10.2 DID YOU OR ANYONE IN THIS HOUSEHOLD OWN OR CULTIVATE ANY VEGETABLE GARDEN **IN 2016 AND/OR 2017**?

GENERAL PLOT DETAILS

☐10.3 HOW DID YOU USE THIS PLOT DURING THE (SEASON)?

1 … cultivated; 2 … rented out; 3 … given out; 4 … fallow; 5 … forest; 6 … other

☐10.4 **ASK IT ONLY IF THE PLOT WAS RENTED OUT**: WHAT WAS THE TOTAL INCOME FROM RENTING OUT THIS PLOT DURING THE (SEASON)?

write "0" if given out for free

☐10.5 WHAT WAS THE MAIN CROP CULTIVATED ON THIS PLOT IN THE (SEASON)?

crop name (English or Garo)

☐10.6 WHAT WAS THE OWNERSHIP STATUS OF THIS PLOT IN THE (SEASON)?

1 … owned; 2 … used free charges; 3… rented in; 4 … shared-rent; 5 … shared-own

ORGANIC FERTILIZERS

☐ 10.10 HOW MUCH OF ORGANIC FERTILIZER WAS USED?

if none write "00"; kilograms

☐ 10.11 HOW MUCH WAS PURCHASED?

kilograms

☐ 10.12 WHAT WAS THE TOTAL VALUE OF ORGANIC FERTILIZER PURCHASED?

rupees

INORGANIC FERTILIZER

☐ 10.13 WHAT TYPE OF INORGANIC FERTILIZER DID YOU USE?

if none, write "00"

☐ 10.14 WHAT QUANTITIES OF THIS INORGANIC FERTILIZER DID YOU USE?

if none, write "00"; kilograms

☐ 10.15 WHAT WAS THE TOTAL VALUE OF INORGANIC FERTILIZER PURCHASED?

rupees

☐ 10.16 WHY DID YOU CHOOSE TO USE THIS SPECIFIC TYPE AND THIS QUANTITY OF INORGANIC FERTILIZER?

1 … advice by agricultural officer; 2 … own experience; 3 … neighbour advice;
4 … agricultural cum nutritional project experts; 5 … other

PESTICIDE

☐ 10.17 WHAT TYPE OF PESTICIDE HAVE YOU APPLIED?

1 … insecticide; 2 … herbicide; 3 … fungicide; 4 … other if none, write "00"

☐ 10.18 WHAT QUANTITIES OF THIS PESTICIDE HAVE YOU USED?

write the value and: 1 for kg, 2 for litre and 3 for millilitre

☐ 10.19 WHAT WAS THE TOTAL VALUE OF PESTICIDE PURCHASED?

rupees

☐ 10.20 WHY DID YOU CHOOSE TO USE THIS SPECIFIC TYPE AND THIS QUANTITY OF PESTICIDES?

1 … advice by agricultural officer; 2 … own experience; 3 … neighbour advice;
4 … agricultural cum nutritional project experts; 5 … other

INPUTS ON CREDITS

☐ 10.21 HAVE YOU RECEIVED ANY SEEDS, FERTILIZERS, PESTICIDES FOR (PLOT) ON CREDIT TO BE PAID LATER DURING (SEASON)?

1 … yes; 2 … no

☐ 10.22 WHICH KIND OF INPUT YOU RECEIVED ON CREDIT?

1 … seeds; 2 … org. fertilizer; 3 … inorganic fertilizer; 4 … pesticides; 5 … other

GENERAL

☐ 10.23 DID YOU CULTIVATE THIS PLOT IN THE (SEASON)?

1 … yes; 2 … no

☐ 10.24 WHY DIDN'T HARVEST ANY CROP ON THIS PLOT?

1 … drought; 2 … rains; 3 … fire; 4 … insects; 5 … animal; 6 … theft; 7 … disease; 8 … other

☐ 10.25 APPROXIMATELY, HOW MUCH OF THE PLOT WAS PLANTED WITH (CROP)

1 … ¼; 2 … 2/4; 3 … 3/4; 4 … entire area

☐ 10.26 WAS CULTIVATION INTERCROPPED?

1 … yes; 2 … no

19.CROP BY PLOT

FOCUS ON RICE

SEEDS AND SOWING LOSSES

☐ 11.1 WHAT WAS THE AREA SOWN WHIT (CROP) IN THE (SEASON)?

amount and unit (1 … ha, 2 … m², 3 … bigha)

☐ 11.2 HOW MANY SEEDS OR PLANT DID YOU USE FOR SOWING?

amount and unit (1 … kg, 2 … grams, 3 … n° plant)

☐ 11.3 DID YOU PURCHASE ANY (CROP) SEEDS IN THE (SEASON)?

1 … yes; 2 … no

☐ 11.4 WHAT TYPE OF SEEDS DID YOU PURCHASE?

1 … traditional; 2 … improved

☐ 11.5 WHERE DID YOU TAKE THE SEEDS?

1 … NGO's; 2 … agricultural cum nutritional project; 3 … agricultural office; 4 … market; 5 … another assoc. (write the name); 6 … own produced;

☐ 11.6 WHAT WAS THE CAUSE OF LOSSES DURING SOWING?

1 … birds; 2 … animals; 3 … insects; 4 … disease; 5 … theft; 6 … other

HARVEST E HARVEST LOSSES

☐ 11.7 WHAT WAS THE AREA HARVESTED IN THE (SEASON)?

please write value of surface and unit (1 … ha, 2 … m², 3 … bigha)

☐ 11.8 WAS THE AREA HARVESTED LESS THEN AREA PLANTED?

if yes, what is the surface of this area? please write value of surface and unit (1 … ha, 2 … m², 3 … bigha)

☐ 11.9 WHAT WAS THE REASON IT WAS LESS THAN THE AREA PLANTED?

1 … drought; 2 … rains; 3 … fire; 4 … insects; 5 … animal; 6 … theft; 7 … disease; 8 … other

☐ 11.10 WHAT WAS THE QUANTITY HARVESTED?

If "no" go to the next question! *yield in kilograms*

☐ 11.11 **IF IT IS NOT HARVESTED YET**, WHAT COULD BE THE QUANTITY HARVESTED?

kilograms

☐ 11.12 WHAT WAS THE MAIN CAUSE OF THESE LOSSES?

1 …drought; 2 … birds; 3… animals; 4 … insects; 5 … disease; 6 … theft; 7 … other

20.CROPS HOUSEHOLD TOTAL

STORAGE AND POST-HARVEST LOSSES

☐ 12.1 HOW MUCH PRODUCT HAVE YOU STORAGE DURING (SEASON)?

kilograms

☐ 12.2 WHICH IS YOUR MAIN STORAGE METHOD?

1 … locally made traditional structure; 2 … improved locally made structure; 3 … modern store; 4 … sacks/open drum; 5 … airtight drum; 6 … unprotected pile; 7 … ceiling; 8 … other

☐ 12.3 HAVE YOU DONE ANYTHING TO PROTECT THE STORED CROP?

1 … none; 2 … spraying; 3 … smoking; 4 … other

☐ 12.4 WHAT KIND OF PRODUCT DID YOU USE?

write the name

□ 12.5 WHEN YOU STORE (CROP), WHAT IS USUALLY THE MAIN PURPOSE OF STORING IT?

1 … food for household; 2 … to sell at the higher price; 3 … seed for planting; 4 … other

□ 12.6 HOW MUCH PRODUCT HAVE YOU LOST DURING STORAGE?

kilograms

□ 12.7 WHAT IS THE MAIN REASON FOR LOSS?

1 … rotting; 2 … insects; 3 … rodents, pests; 4 … theft; 5 … other

SALES

□ 12.8 WHAT WAS THE QUANTITY SOLD?

kilograms

21.PERMANENT CROPS BY PLOT

PLEASE LIST THE 4 MOST IMPORTANT FRUIT TREES BY IMPORTANCE

□ 13.1 WHAT WAS THE TOTAL AMOUNT OF (FRUIT) HARVESTED IN THE PAST 12 MONTHS?

1 … kilograms; 2 … bags

□ 13.2 HOW MUCH PRODUCT HAVE YOU LOST DURING THE HARVEST?

kilograms

□ 13.3 WHAT IS THE REASON FOR LOSS

1 … rotting; 2 … insects; 3 … rodents, pests; 4 … theft; 5 … other

STORAGE AND POST-HARVEST LOSSES

□ 13.4 WHAT IS YOUR MAIN METHOD OF STORAGE?

1 … locally made traditional structure; 2 … improved locally made structure; 3 … modern store; 4 … sacks/open drum; 5 … airtight drum; 6 … unprotected pile; 7 … ceiling; 8 … other; 9 … none

□ 13.5 DID YOU DO ANYTHING TO PROTECTED STORED CROP?

1 … yes; 2 … no

□ 13.6 WHAT DID YOU DO?

1 … spraying; 2 … smoking; 3 … other

□ 13 .7 HOW LONG THE PRODUCT IS STORED BEFORE CONSUMPTION / SALES

months

□ 13.8 HOW MUCH PRODUCT HAVE YOU LOST DURING STORAGE?

kilograms

□ 13.9 WHAT IS THE REASON FOR LOSS?

1 … rotting; 2 … insects; 3 … rodents, pests; 4 … theft; 5 … other

SALES

□ 13.10 WHAT WAS THE TOTAL QUANTITY SOLD OF THE QUANTITY COLLECTED?

Kilograms

15.   PROCESSED AGRICULTURAL PRODUCTS

DID THE HOUSEHOLD PROCESS ANY OF THE PRODUCTS HARVESTED ON THE FARM IN THE LAST 12 MONTHS?

(IF YES FILL QUESTIONS 1 TO 5, IF NO GO TO PART 16)

☐ 15.1 WHAT IS THE PRODUCT PRODUCED FROM (CROPS NAME)?

codes products: 1 … flour; 2 … seed; 3 … chips; 4 … juice; 5 … thread; 6 … pulp; 7 … rubber; 8 … other

☐ 15.2 WHAT IS THE QUANTITY PRODUCED IN THE LAST 12 MONTH?

1 … kg; 2 … litre

☐ 15.3 HOW MUCH WAS SOLD?

1 … kg; 2 … litre

☐ 15.4 HOW MUCH (CROP) DID YOU USE AS INPUT FOR THE SOLD (PRODUCT)?

kilograms

☐ 15.5 HOW LOSSES AND WASTE ARE USED?

kilograms

22.LIVESTOCK

DID THE HOUSEHOLD OWN ANY ANIMALS IN THE LAST 12 MONTHS?

(IF YES FILL QUESTIONS 1 TO 8, IF NO GO TO PART 17)

☐ 16.1 HOW MANY TRADITIONAL OR IMPROVED (HEADS) DOES THIS HOUSEHOLD CURRENTLY OWN?

number type: 1 … indigenous; 2 … improved

☐ 16.2 HOW MANY (HEADS) WHERE BORN IN THE PAST 12 MONTHS?

number

☐ 16.3 HOW MANY (HEADS) HAVE YOU SOLD ALIVE IN THE PAST 12 MONTHS?

number

☐ 16.4 HOW MANY (HEADS) DID YOU SLAUGHTERING IN THE PAST 12 MONTHS?

number

☐ 16.5 HOW MANY (HEADS) HAVE YOU LOST TO DISEASE IN THE PAST 12 MONTHS?

number

☐ 16.6 HOW MANY (HEADS) HAVE YOU LOST TO OTHER REASON IN THE PAST 12 MONTHS?

number

☐ 16.7 WHAT IS THE (HEADS) WEIGHT AT SALE/SLAUGHTERING?

number

☐ 16.8 DID YOU COLLECT ANY FAECES? IF YES, HOW DID HOUSEHOLD DO WITH IT?

1 … yes;

23.OTHERS HUSBANDRY PRODUCTION

DID THE HOUSEHOLD PROCESS ANY OF LIVESTOCK BY PRODUCTS ON THE FARM IN THE LAST 12 MONTHS?

(IF YES QUESTIONS 1 AND 2, IF NO GO TO PART 19)

☐ 17.1 WHAT IS THE QUANTITY PRODUCED IN THE LAST 12 MONTH?

type. 1 … kg; 2 … litre; 3 … pieces

☐ 17.2 HOW MUCH WAS SOLD?

type: 1 … kg; 2 … litre; 3 … pieces

19.   FISHERY AND AQUACULTURE

DID THE HOUSEHOLD FISHED OR OPERATE A FISH FARM IN THE LAST 12 MONTHS?

(IF YES FILL QUESTIONS 1 AND 6, IF NO GO TO PART 20)

☐ 19.1 DID THE HOUSEHOLD USE THIS FISHING METHODS?

1 … yes; 2 … no

☐ 19.2 DURING THE LAST 12 MONTHS, HOW MANY DAYS PER WEEK DID YOUR HOUSEHOLD FISH ON AVERAGE?

days

☐ 19.3 WHAT WAS THE AVERAGE QUANTITY OF YOUR DAILY CATCH ON AVERAGE?

kilograms

☐ 19.4 HOW MUCH, IF ANY, OF THE DAILY CATCH DID YOU SELL AS FRESH FISH?

kilograms

☐ 19.5 IN THE LAST 12 MONTHS, HOW MANY KILOGRAMS OF THE DAILY CATCH WAS SMOKED OR DRIED?

kilograms

☐ 19.6 HOW MUCH, IF ANY, OF THE DAILY CATCH DID YOU SELL AS DRIED OR SMOKED FISH?

kilograms

24.EXTENSION

☐ 20.1 DID YOU RECEIVE ANY ADVICE FROM (SOURCES) ABOUT …

1 … yes; blank … no.

☐ 20.2 DID YOU RECEIVE ANY … FROM (SOURCES)?

1 … yes; blank … no.

Harry Sullivan: "No, Doctor, I'm the doctor, and I say you're not fit!"
The Doctor: "You may be a doctor. But I'm THE Doctor. The definite article, you might say."
Fourth Doctor | Doctor WHO | Robot | BBC - 1974