SustInAFRICA

Sustainable intensification of food production through resilient farming systems in West & North Africa

Deliverable D5.1

Socioeconomic and environmental screening metrics

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 861924

Abstract

A key role of **WP5: Sustainability, replicability & exploitation of successful practices,** is to screen the methods, technologies, and solutions developed by SustInAfrica for climate resilience, impact on gender, nutrition and the environment, and the potential for replicability and scaling. This report presents an initial list of metrics for assessing these criteria and the data required to use these metrics, which will form part of the indicator toolbox developed by WP1. As far as possible the metrics are internationally accepted standard metrics or metrics the investigators are already using.

Contents

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List of abbreviations and acronyms

AEZ	Agro-ecological zoning
BCC	Behaviour Change Communication
CGIAR	Climate Change Agriculture and Food Security
CIHEAM	Mediterranean Agronomic Institute of Bari
CSA	Climate Smart Agriculture
DHS	Demographic and Health Surveys
FAO	Food and Agriculture Organization
FCS	Food Consumption Score
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
MDDW	Minimum Dietary Diversity for Women
SDG	Sustainable Development Goals
SHA	Self Help Africa
UAA	Utilised Agricultural Area
UN	United Nations
UNDESA	United Nations Department of Economic and Social Affairs
UNICEF	United Nations Children's Fund
UN WOMEN	United Nations Entity for Gender Equality and the Empowerment of Women
USAID	United States Agency for International Development
WFP	World Food Programme
WHO	World Health Organisation
WP	Work Package

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1. Introduction

The overall objective of WP5: Sustainability, replicability & exploitation of successful practices, is to ensure the lasting impact of African-EU joint research at the local level by screening the methods, technologies, and solutions developed by SustInAfrica for climate resilience, impact on gender, nutrition and the environment, and the potential for replicability and scaling before developing exploitation strategies, which will include costed business plans for commercially viable technologies and extension strategies for Public Goods.

The specific objectives are to:

- **OB5.1:** Gain deep understanding of the potential impacts of the technologies implemented under ***SustInAfrica***:
- Assess impact of methods, technologies and solutions developed by ***SustInAfrica*** on the environment, social and economic systems.
- **OB5.2:** Ensure the replicability of ***SustInAfrica*****:** Assess the replicability and readiness for scaling of the methods, technologies and solutions developed by ***SustInAfrica***.
- **OB5.3:** Ensure exploitation of ***SustInAfrica*****'s outcomes:** Develop sustainable costed strategies, models and business plans for scaling-up/scaling-out of ***SustInAfrica*** methods, technologies and solutions through private and public investors.

To do this WP5 will:

- Develop a system to assess sustainability, resilience, gender equity, agricultural performance and impact on ecosystem services against international metrics (Fig. 1).
- Set up approaches to ensure sustainability and resilience of changed agro-food systems
- Explore and develop business models and commercialisation pathways
- Prepare policy and industry briefs and recommendations

The first stage of the process is to agree on the metrics that will be used to check the actual or potential impact of the research outputs, technologies, products and practical solutions, hereafter referred to as "outputs", on Gender Equality, Nutrition, the Environment, and their resilience to current and future climatic shocks and stresses. The data required to use these metrics will form part of the indicator toolbox developed by WP1.

This report proposes an initial set of metrics for the indicator toolbox and includes the metrics required for the Replicability Assessment. As far as possible the metrics are internationally accepted standard metrics, such as UNICEF/WHO/WFP Nutrition Indicators and UN FAO's definition of Climate Smart Agriculture. The benefit of using these indicators is that the methodologies are well-tested, several of these indicators link directly with the SDGs (Sustainable Development Goals), the ***SustInAfrica*** investigators are familiar with collecting them, and they will allow comparisons with other work.

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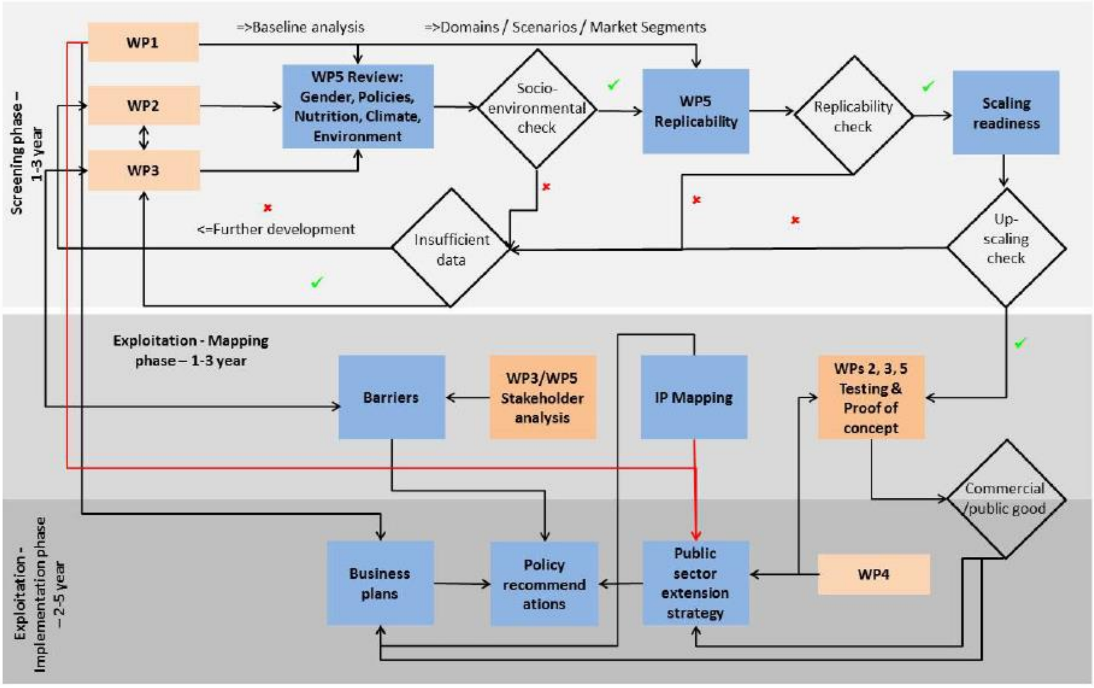

Figure 1: Pathways to ensuring replicability & technology readiness prior to upscaling.

2. Nutrition Metrics

The Value of Nutrition within Agriculture Programming

Hunger and malnutrition remain a significant challenge globally, especially in Sub-Saharan Africa. The GHI (Global Hunger Index), a composite of undernutrition (insufficient calorie intake), under five wasting, stunting and mortality, estimates the level of hunger in Sub-Saharan Africa at 28.4% (von Grebmer et al., 2019), slightly down from 2010 estimates but still considered serious. There are large between and within country variations in the level of hunger. Furthermore, rural communities are disproportionally negatively impacted, in terms of poverty, by food and nutrition insecurity (IFPRI, 2019) and these are the communities/regions that in general produce and supply the most food. Within the SustInAfrica countries of operation Niger and Burkina Faso have a serious/high GHI score, Egypt and Ghana moderate GHI score and Tunisia a low GHI score (von Grebmer et al., 2019).

Traditionally nutrition has been predominately addressed within the health sector. The Nutrition Specific interventions (10 identified) implemented through the health centre system are focused on addressing maternal and child undernutrition with a bias to a curative approach. These recognised interventions include support such as pre-natal care in nutrition and health, care of the new-born and

> **Nutrition-specific interventions or programs** are those that address the immediate determinants of foetal and child nutrition and development—
> adequate food and nutrient intake, feeding, caregiving and parenting practices, and low burden of infectious diseases.
> **Nutrition-sensitive interventions or programs** are those that address the underlying determinants of foetal and child nutrition and development—
> food security; adequate caregiving resources at the maternal, household and community levels; and access to health services and a safe and hygienic environment—and incorporate specific nutrition goals and actions.
> Source: Ruel et al, 2013.

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infants/young children up to 24mths, micronutrient supplementation and treatment of acute malnutrition. The Maternal and Child Lancet Series (Bhutta et al., 2013) indicated that if there was 90% coverage of these nutrition specific interventions, it would only reduce malnutrition by 15-20% and this level of coverage especially in rural communities would be challenging. To further address malnutrition it is suggested the need for a community approach to nutrition specific interventions together with nutrition sensitive interventions addressing women's empowerment, agriculture, food systems, education, employment, social protection, and safety nets—they can greatly accelerate progress in countries with the highest burden of maternal and child undernutrition and mortality (Bhutta et al., 2013).

The agriculture sector over the years has mainly focused on food production with a particular emphasis on increasing yields of the staple crops to address hunger with an assumption that improved food security would translate to improved nutrition outcomes. However, in more recent years there is a realisation that for *Food and Nutrition Security* there is a need for a more holistic approach with the production of more diverse variety of foods for a healthy balanced diet together with access to health services, appropriate caring practices and a healthy environment (Pangaribowo et al., 2013). This illustrates the need for a multi-sectoral approach to combat hunger and malnutrition.

Nutrition-sensitive agriculture is a relatively new concept. However, it has been realised by donors, governments and development agencies that there is a need for agriculture to better support nutrition. This is reflected in **SDG 2 – Zero Hunger** where agriculture is specifically mentioned as part of the solution to reducing hunger. Some countries are now reflecting nutrition better within agriculture policies and agricultural development programmes. Agriculture to Nutrition frameworks and pathways have been developed to support and understand the ways in which agriculture may contribute to improved nutrition. In the last decade, a body of research has been done looking at different elements of nutrition and agriculture with mixed results. Results can be context specific and

SDG 2: Zero Hunger

2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.

2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.

2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including 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.

2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.

2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed.

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vary depending on market access, women's empowerment and many other factors. Generally, there is a positive association between crop production diversity and dietary diversity, however the relationship between crop diversity and nutritional status is weaker (Ruel et al., 2018). The timeframe for some of the studies was relatively short at 1-2 years, possibly too short to see nutritional impact. A strong behaviour change communication (BCC) component to promote optimal diets and child feeding practices together with a focus on women's empowerment, through agriculture, are key to enhancing positive outcomes on diets and other nutrition outcomes (Ruel et al., 2018).

SustinAfrica is not designed as a nutrition project, or even as a Nutrition Sensitive Agriculture project (Agriculture to Nutrition Project, A2N), however the outputs of the project should ideally improve the nutritional status of women and children or, at the very least **Do No Harm**, i.e. not undermine international efforts to improve nutrition enshrined in **SDG 2: Zero Hunger**.

There are several frameworks and pathways developed to assist in highlighting and understanding the various complex linkages between agriculture, health and nutrition. For the SustInAfrica programme we have decided to use the IFPRI (International Food Policy Research Institute) modified framework (Fig. 2). IFPRI looks at the various pathways that agriculture/livelihoods can potentially impact positively, on mother and child health/nutrition outcomes, as identified by Gillespie, Harris, and Kadiyala (2012) in the Agriculture-Nutrition Disconnect in India - IFPRI Discussion Paper.

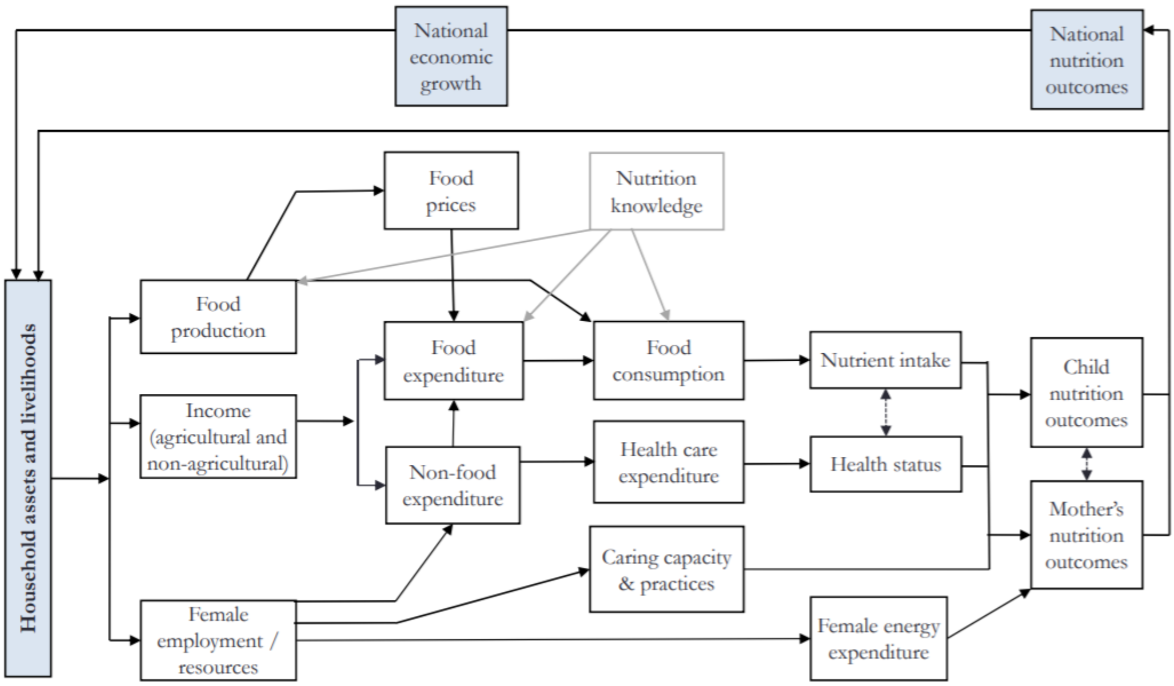

Figure 2: Pathways from agriculture to nutrition. Adapted from: Stuart Gillespie, Jody Harris, and Suneetha Kadiyala (2012). The Agriculture-Nutrition Disconnect in India, What Do We Know? IFPRI Discussion Paper 01187

As can be seen in Fig. 2 there are a number of pathways where the impact of agriculture interventions may influence nutrition outcomes; food production can lead to increased access to food in the household and increased income from excess food, which can impact on food and non-food expenditure. Food production also influences food prices, which again impacts on income, expenditure and the purchase of food. Agricultural income can be either from excess food production and or cash crops, or labour. Women's status and empowerment can positively impact when access to and control of resources is increased. However, women's time can be positive or negative depending on whether agriculture initiative is labour intensive or not. Similarly, the impact on women's health can be positive or negative, depending on exposure to toxic agents, or if energy intake and expenditure are

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imbalanced (labour intensive work). For the agriculture-to-nutrition pathway to achieve success in terms of nutrition outcomes, highlights the need for an enabling environment in terms of the following:
1) food market environment.
2) natural resource environment
3) health, water and sanitation
4) nutrition/health knowledge and norms.

It is important to realise that improved incomes do not automatically lead to reductions in malnutrition and where this happens is it at a slow rate (Shekar, 2005). Research suggests that where income increase people are able to increase expenditure on non-food items and a more diverse diet impacting on improvements on micro-nutrient uptake but not necessarily on nutrition, in particular child stunting (Haddad, 2000).

As seen from research to date there are linkages between agriculture and improvements in dietary diversity however, there is no clear pathway on how agriculture can support the reduction of malnutrition, particularly in countries where there is a high malnutrition burden. Research is ongoing, and in coming years there will be a wealth of new knowledge. However, if agriculture is to positively impact on nutrition it is essential to have explicit nutritional goals and activities embedded within agriculture programming. To date research has shown that implementing programmes in production diversity, micro-nutrient rich crops (including biofortified crops), dairy and or small animal rearing can improve the production and consumption of these targeted commodities, impacting positively in dietary diversity at household level and sometimes maternal and child level (Ruel et al., 2018).

Embedding Nutrition with the SustInAfrica programme

It is important that the SustInAfrica programme takes on a nutrition sensitive approach within all its planned interventions, to support the improvement in health and wellbeing of the households and communities in the areas of operation. FAO (Food and Agriculture Organization) defines Nutrition-Sensitive agriculture as "*A food-based approach to agricultural development that puts nutritionally rich foods, dietary diversity, and food fortification at the heart of overcoming malnutrition and micronutrient deficiencies*". This approach stresses the multiple benefits derived from enjoying a variety of foods, recognizing the nutritional value of food for good nutrition, and the importance and social significance of the food and agricultural sector for supporting rural livelihoods. The overall objective of nutrition-sensitive agriculture is to make the global food system better equipped to produce good nutritional outcomes

In addition to these criteria Self Help Africa (SHA) is committed to ensuring that nutrition within agriculture incorporates the following:
a. In-depth context analysis to ensure that interventions are appropriate and respond to local needs
b. Training/knowledge transfer on basic nutrition, food utilization, preservation, and storage to improve nutrition outcomes
c. Working closely with relevant line ministries, including Health, Agriculture and Local Government which allows for a more comprehensive lens to be used in approaching nutrition needs and contributing to long-term sustainability and impact
d. Working closely with Nutrition Coordinating Committees at national, district, and sub district level where appropriate
e. When nutrition-specific training is part of a programme, targeting the nutrition and health needs of vulnerable groups, specifically with a focus on pregnant/lactating women and young children, linking strongly with community health centres
f. Promoting best practices on basic WaSH practices at individual, household, and community levels in collaboration with relevant stakeholders (Government, NGOs, etc.)

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g. Promoting gender sensitisation within households and communities
h. Enhancing knowledge transfer using diverse and creative methods such as developing local recipes, cooking demonstrations, mapping of the food availability calendar at community level, role play

WP5 will test the possible effects of SustInAfrica outputs on each pathway to estimate the potential impact, positive or negative, on nutrition. To do this the following metrics will be collected. SustInAfrica does not propose to collect anthropometric data but will rely on dietary recall surveys and secondary data to build a picture of nutrition risks and opportunities within the farming systems.

Where to start

Is important to understand the country and regional context in terms of nutrition. Much of this information can be found in secondary data analysis from the national DHS (demographic health surveys) which are generally collected every 5 years. Other resources include UNICEF, FAO and WHO data and reports. From the secondary data national, regional and county/district data can be found in terms of maternal and child malnutrition (wasting, stunting and underweight). Other data can be found in terms of micro-nutrient malnutrition through the country DHS and other studies by UNICEF/WHO and others.

During the baseline surveys it would be valuable to get an understanding of what crops are grown in what seasons and to understand what is available for consumption and sale, and then when/if there are seasonal hunger gaps (Seasonal Availability Calendar). These data can be collected during focus group discussions at baseline and will be useful in decisions on crop production.

Conduct household baseline Food Consumption Score (FCS) (adapted from WFP FCS) at baseline. This is a 7-day recall of what foods from the different food groups have been consumed by the household in the previous 7 days. These data will give an understanding of what the household dietary diversity was, prior to start of the intervention period. Follow-on data collection should be collected seasonally as there may be significant variations on household dietary diversity at different seasons. Data comparisons need to compare changes in the same season. Research indicates that dietary diversity can change with nutrition sensitive interventions therefore it would be valuable to track.

The "Minimum Dietary Diversity Score for Women" (WDDS – women's dietary diversity score) targeting women of reproductive age 15-49 years is an important tool developed by FAO/USAID to measure impact of interventions from a nutrition perspective. This 24hr dietary recall will give accurate information as the timeframe is short and very specific (24hr recall -what was eaten in the previous 24hrs). Changes in WDDS is generally reflective in changes in diet in the household. It can also look at different age groups such as adolescent nutrition and other age groups if of specific interest.

Interventions will probably impact on water in terms of access and supply (irrigation schemes etc.) and as water is a critical resource for good health and nutrition it is important to track. Changes in quality of water may impact negatively/positively in health and nutrition outcomes. This information should be collected by testing for water quality and secondary data from health centres close by can identify if there are changes in illness trends - such as increase in waterborne illnesses such as diarrhoea, malaria, schistosomiasis etc.

Basic nutrition indicators

Minimum Dietary Diversity for Women (MDDW)

This metric (previously known as the Women's Dietary Diversity Score, WDDS) was developed by FAO/USAID to measure impact of interventions from a nutrition perspective. The metric measures the number of food groups consumed by women of reproductive age, 15-49 years, in the past 24 hours. As the timeframe is short dietary recall is very accurate. Changes in WDDS is generally reflective in changes in diet in the household. It can also look at different age groups such as adolescent nutrition and other age groups if of specific interest. The data will be disaggregated by Farming System and will be measured during the baseline and cross checked with secondary data from UNICEF and DHS.

Household Food Consumption Score (HFCS)

WP5 proposes to use SHAs adaptation of the standard WFP score based on 7-day recall of 7 weighted food groups: Starch staples, pulses, vegetables, fruit, fats, sugars, meat/fish/eggs, milk/dairy and condiments. The sum of the weighted food group values is the HFCS. Household data will be collected at the baseline and then seasonally using SHAs digital tool, which is based on a WFP food consumption score card. This data will give an understanding of what the household dietary diversity was, prior to start of the intervention period and how dietary diversity changes with seasons.

Stunting rates

Stunting rates, measured as **Height for Age scores** or **Mid Upper Arm Circumference (MUAC),** are standard international indicators of long-term malnutrition caused by inadequate diet and feeding practices, poor sanitation, micronutrient deficiencies, unsafe food, presence of nutrition inhibitors in the diet, repeated gastro-intestinal infections and high parasite burdens. Stunting rates are described as Z-scores. WP5 will not collect data but will review secondary data to build a picture of risks within the farming systems, disaggregated by AEZ/ farming system from UNICEF and DHS.

Severe Acute Malnutrition (SAM) and Global Acute Malnutrition (GAM) Rates

Acute malnutrition is an indicator of short-term acute deficiencies in food intake and is measured using **Weight for Age Scores and Mid Upper Arm Circumference** (MUAC). These rates are international indicators. Stunting rates are described as Z-scores. SustInAfrica does not propose to collect anthropometric data but rely on secondary data to build a picture of risks within the farming systems (Fig. 3) from UNICEF and DHS.

Food calendars/ seasonal availability

The calendar will identify seasonal food gaps (lean/ hunger season). To maximise impact on nutrition SustInAfrica outputs should increase food availability during the food gaps, either through the off-season production of crops or through improving the yield and storage of main season crops. The survey will be conducted during the baseline using SHAs digital tool.

Micronutrient deficiencies/ hidden hunger

Micronutrient deficiencies in the diet (Iodine, zinc, iron, vitamin A, calcium, selenium) are common in Africa and have a significant impact on maternal and child growth and development. As with Food Safety WP5 will identify potential food safety risks in each of the farming systems from secondary data but will not conduct specific research to identify micronutrient deficiencies, using IFPRI's Global Hunger Index, research from UNICEF and DHS.

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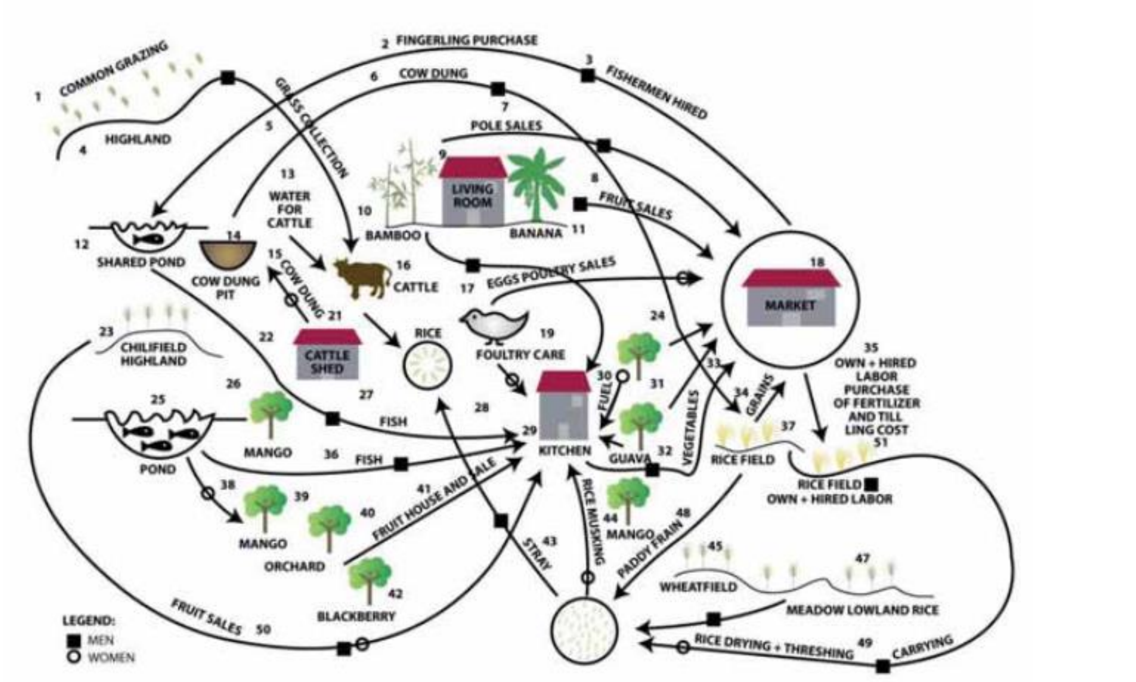

(Adapted from FAO, 2001a.)

Figure 3: Example of a visual representation of a Farming System, showing nutrient/ energy flows through the system (FAO, CARE Bangladesh

Food Production, Processing, and storage

Will the technology improve the availability and quality of food at the household level, or increase household income sufficiently to enable households to purchase food at local markets? This will be assessed from the data collected from the field trials.

Food production at the household Level

This will be assessed from the following WP1 and WP3 metrics:

- **Holding size**
- **Farming System Analysis**
- **Land area**
- **Harvested Yield, Yield Gap**
- **Livestock productivity**
- **Crop diversity.** Crop diversity is a useful proxy indicator for dietary diversity (Kumar et al, 2015).

Food safety

WP5 will identify potential food safety risks in each of the farming systems that may impact on nutrition. The best-known examples are the risk of inhibition of iodine uptake in poorly processed cassava and the high levels of arsenic in rice grown in the Ganges Valley, however other risks involve contamination of the food in the field, during harvesting and during storage by mycotoxins, and biological contamination due to dirty water and unsafe handling. This will be a desk study based on the Farming Systems Analysis and secondary data. Food safety will be based on the following WP1 & WP3 metrics:

- **Farming System Analysis**

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- **Yield quality**
- **Storage**
- **Water: Heavy metals, fluorine & Microbial contamination**

Yield Quality

The harvests will be assessed against appropriate quality standards as this will provide a standardised indication of quality, marketability and safety. These are parameters that the SustinAfrica investigators routinely measure and, with the possible exception, of aflatoxin testing equipment, own the required equipment (grain spears, moisture meters, hand lenses). These should be national or international standards: Ghana National Bureau of Standards, World Food Program (fig. 4), IFOAM, etc.

WFP wfp.org	**Technical Specifications for maize**
4.1 General requirements	
Organoleptic:	Natural state, smell and colour
Moisture:	**13.5%** w/w max.
Other colour maize:	**5.0%** w/w max.
Pest damage grains:	**3.0%** w/w max.
Rotten & diseased grains:	**4.0%** w/w max.
Discoloured grains:	**1.0%** w/w max.
Immature/shrivelled grains:	**2.0%** w/w max
Total defective grain:	**5.0%** w/w max.
Inorganic matter:	**0.5%** w/w max.
Foreign matter:	**1.0%** w/w max.
Other grains:	**2.0%** w/w max.
Filth:	**0.1%** w/w max.
Live insect:	Nil
Dead insect:	max 10 dead insects per kg
Broken grains:	**4.0%** w/w max.
4.3.3 Mycotoxins	Total Aflatoxins (B1+B2+G1+G2) shall not exceed 20ppb

Figure 4: Example of a quality standard. the WFP quality standard for maize (V13.1). Note that this specification exceeds the maximum Total Aflatoxins levels (B1+B2+G1+G2) set by most African countries (10ppb).

Food storage

Will the technology have a positive impact on crop storage and processing? The baseline will assess current storage facilities and track the quality of the crop harvested against national, international and trade standards, like the WFP standards. Food storage will be assessed using the WP1 & WP3 metric: **Storage**

Quality of Drinking and irrigation water

Interventions will probably impact on water in terms of access and supply (irrigation schemes etc) and as water is a critical resource for good health and nutrition, it is important to track. Changes in quality of water may impact negatively/positively in health and nutrition outcomes. This information should ideally be collected by testing for water quality, however this may not be cost effective and WP5 proposes to use proxy indicators and secondary data from health centres close by, to identify if there

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are changes in illness trends - such as increase in waterborne illnesses such as diarrhoea, malaria, schistosomiasis, etc.

Water sources

The baseline will collect data on the type of water sources in the target communities. WP5 does not intend to conduct water testing of all water sources but will use water sources types as a proxy Indication of exposure to water borne diseases that can impact on nutrition.
Indicators: **Water sources**

Water quality: Microbial and Chemical contamination (heavy metals, fluoride)

Some water sources for drinking and irrigation will be tested for biological and chemical contamination as part of the environmental indicators. Arsenic in irrigation and drinking water pumped from shallow wells in the Ganges Valley has created a public health crisis and all donor funded irrigation and potable water projects are now expected to test for heavy metals during planning and commissioning. Fluoride in ground water is a serious problem in the East African Rift Valley, causing irreversible damage to teeth and bones. WP5 will conduct a literature review to identify risks in the project areas and conduct interviews with key staff of National Geology/ Mineral Resources/ Water Depts. Water samples will be tested for arsenic and other heavy metals using WHO testing protocol. Contamination of shallow wells with animal manure increase the transmission of a range of pathogens. Cryptosporidium contamination of wells shows a strong positive correlation with risk of child stunting. Crypto testing is expensive and E coli testing can be used as a proxy indicator of contamination (Marshak, Young and Radday, 2015).

Indicators:
Water quality: biological tests, Chemical contamination (heavy metals, fluoride)

Agricultural Income and Food expenditure

Will the technology increase income sufficiently to enable households to buy foods from the market to diversify diets and purchase foods not available locally? This will be assessed from the **Gross Margin Analysis.**

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3. Suitability for current and future climates and resilience to climatic shocks and stresses

Most of the agroecological zones covered by **SustInAfrica** are subhumid, semi-arid or arid and so experience frequent and extended droughts. Traditional farming systems in these areas are well-adapted to droughts and all the outputs from **SustInAfrica** must further increase the resilience of farming systems to droughts in order to contribution to **SDG 13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries**. The region is experiencing changes in the climate and so in addition to assessing the suitability of the outputs to current climatic conditions WP5 will assess the suitability for future climates.

WP5 proposes to use the **Climate Smart Agriculture** framework developed by FAO. FAO defines **Climate-Smart Agriculture** as agricultural practices (FAO CSA Sourcebook 2013) that:
- Sustainably increase agricultural productivity and incomes (Assets).
- Adapt and build resilience to climate change (Vulnerability, Adaptation and Resilience).
- Reduce and/or remove greenhouse gas emissions, where possible (Mitigation).

To determine if the outputs solutions are Climate Smart, WP5 will review the outputs against FAOs definition of Climate Smart Agriculture. WP5 acknowledges that there is disagreement over the use of the term **Climate Smart Agriculture** (Pimbert, 2015, CIDSE 2014) however the FAO definition is clear and succinct and so is ideal for screening the SustInAfrica outputs.

Sustainably increase agricultural productivity and incomes.

The crop yield data, gross margin analysis and returns to family labour data will be used to estimate the potential of the research outputs to increase agricultural productivity and the incomes of farmers.

Adapt and build resilience to climate change

To assess the resilience to current and future climates WP5 will consider:
Exposure: What are the climatic changes and shocks to which target farmers will be exposed? Changes in rainfall and rainfall patterns and changes in temperature extremes, especially high night-time temperatures, are critical factors for crops and livestock.

Sensitivity: how will the crops, livestock and natural resources that constitute the farming systems respond to the predicted climate shocks and stresses? (Simpson, 2016)(Burpee, Janet, & Schmidt, 2015)(Self Help Africa, n.d.).

Assessment of exposure to current and future climate shocks and stresses in project areas

WP5 will analysis the current and future **exposure** for each project AEZ using existing data sources. Future exposure will be based on 20-year predictions (2020-2040) for an ensemble of GCMs, downscaled for the project AEZ. Data will be obtained from the following sources:
- World Bank Climate Portal **https://climateknowledgeportal.worldbank.org/**
- CGIAR CCAFS: Downscaled GCM datasets **http://www.ccafs-climate.org/**; **http://www.ccafs-climate.org/climatewizard/** ; CCAFS Climate Analogues Model
- WorldClim: **https://www.worldclim.org/**
- Cropping calendars: FAO **http://www.fao.org/agriculture/seed/cropcalendar/welcome.do**
- Growing seasons: FAO NewLocClim software

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Assessment of the sensitivity of outputs to current and future climate shocks and stresses in project areas

The optimum, maximum and minimum temperature and water requirements for each crop in the project will be assessed from a review of the literature (Casas, 2017). The crop requirements will be assessed against current and future climatic conditions to estimate the suitability of the technologies for future climates.

Reduce and/or remove greenhouse gas emissions.

Assessing **Reduction and/or remove greenhouse gas emissions** is both complicated and controversial. Though many of the practices tested in SustinAfrica will reduce greenhouse gas emissions and help sequester carbon, most of the farmers in the project have very small carbon footprints compared to farmers in Europe and so should not be expected to focus on reducing greenhouse gas emissions on their farms. WP5 therefore proposes that the third Pillar of CSA should not be assessed.

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4. Gender and Social Equality Metrics

Gender and social inequality remain persistent obstacles worldwide and are especially pronounced on the African continent. According to McKinsey's report "Power of Parity Report: Advancing Women's Equality in Africa" (2019), Africa's gender parity stands at 0.58 (with 1 indicating full parity), meaning that for the continent to achieve full parity, it would take 140 years, unless drastic action is taken. Concerns regarding gender and inequality have become increasingly fundamental to development approaches and most organisations have developed approaches to gender analysis and gender mainstreaming. Key literature from the sector includes:

- CARE – Gender Equality and Women's Voice – Guidance Note (2018, 2019)
- FAO, IFAD and World Bank – Gender in Agriculture sourcebook (2009)
- FAO, IFAD and World Bank – Gender Dimensions of agricultural and rural employment: Differentiated pathways out of Poverty (2019)
- The OXFAM Gender Training Manual (1994)

The following section will elaborate on the theoretical basis for the Gender and Social Equality component of the research, using the Access and Control approach to gender analysis. The gender analysis consists in 10 key questions which can be applied to the differing contexts of each target country to best inform a gender-transformative project design. The benefit of using this approach is its flexibility in its application to a wide variety of different populations and contexts. All data will be disaggregated by sex and age.

Gender Analysis

A **gender analysis** is the systematic gathering and examination of information on gender differences and relationships between women and men, girls and boys, in terms of their relative distribution of resources, opportunities, constraints and power, in a given context. A gender analysis is the starting point to identify, understand and redress gender inequalities and look at the different impacts of development interventions on women, men, girls and boys. Once we have that picture of the differences, programmes are designed to overcome barriers and ensure that women and men can participate equally.

Activity Profile	
Who does what?	What do men and women, adults, elders and children, do and where, and when these activities take place?
Ownership, Access and Control Profile	
Who has what?	Who has access to, and control of, resources, and services, and decision making?
Analysis of Factor and Trends	
What is the socio-economic context?	How activities, access and control patterns are shaped by structural factors (demographic, economic, legal, and institutional) and by cultural, religious and attitudinal factors

Table 1: Asian Development Bank Framework

Gender Analysis Checklist

Activity Profile	
Who does what?	**Activities**
• Care and cleaning of the household • Caring for children	

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• Preparation of food • Collecting water and firewood • Caring for the sick/elderly • Family health care • Laundry • Entertaining visitors • Planting • Ploughing • Weeding • Harvesting • Transporting to storage/market • Processing • Petty trading • Membership of savings & Loan groups • Trading (buying and selling) • Community management roles • Membership of village development committee • Others (specify)	
Ownership Access and Control Profile	
Who has what?	**Access to resources**
Who owns: • land, inheritance (government regulations) • house • agricultural instruments • household utensils • bicycle • mobile phone • seeds • livestock • trees	Ownership of assets
Who is responsible for what?	**Roles and responsibilities**
Who is entitled to: • Participate in training • Receive Inputs/services • Buy and sell • Attend community meetings • Undertake development work.	Rights
Who controls income and resources? • Husband • Wife • Jointly • Others	Income and spending power
Who decides what to: • grow, • sell, • eat, • purchase • save	Power /Control
Who gets to benefit from household labour?	Distribution.

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Analysis of Factors and Trends	
What is the socio-economic context?	How activity, Access and Control patterns are shaped by structural (demographic economic, legal, and institutional) and by cultural, religious and attitudinal factors

Table 2: Gender Analysis checklist

Gender and Age disaggregated data sets

Description: Disaggregation by sex and age refers to data or statistics that are designed to show the respective results for female and male separately (women, men, girls and boys) with those under 30 years of age considered as youth. The starting point of all SustInAfrica research projects will be the collection of gender disaggregated data sets. All research projects, field experiments and user trials will involve, as far as possible, equal numbers of male and female farmers/ users/ clients and the research teams will disaggregate their results by the gender of the farmer/ user/ client.

Some data portals for population information:
UNDESA World Population Prospects provides updated population estimates disaggregated by country, sex, age, population density and dependency ratios. Population Division: https://population.un.org/wpp/ . Data on all target countries can also be accessed through UN Women's Data Centre: https://data.unwomen.org/

User Led Design: Women's Involvement in the research

It is worth noting that SustInAfrica was not designed as a gender transformative project. Nevertheless, the technologies produced by the project should be accessible to women and ideally contribute to their empowerment or, at the very least Do No Harm, i.e. not undermine international efforts to improve gender equality and the goals enshrined in **SDG 5.B**.

> **Contribution to SDG 5.B**
> Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women

The overall goal of SustInAfrica is to empower West and North African smallholder farmers and small- and medium-sized enterprises (SMEs) to facilitate sustainable intensification of African farming systems, and to develop and deploy a reference framework on best agricultural practices and technologies, based on a systems approach, and successfully verified for their efficacy to intensify primary production in a self-sufficient, sustainable and resilient manner. The current Best Practice to achieve this is to follow a "**User Led Design**" approach (USAID 2017)., with the farmers closely involved in defining the problems and working with the researchers to identify, design and test solutions, and to refine the solutions through an iterative process. User Led Design should, in theory, reduce the high levels of technology rejection and dis-adoption experienced by most agricultural development research projects. Female farmers must therefore be involved at each stage of the research and their contributions documented in research reports. There are a number of tools available to facilitate the User Led Design process, with different tools appropriate for different research objectives.

Gender Analysis Framework: Activity Profile

For each Farming System the baseline will assess who does what in the farming system, to help understand the roles of men, women and children and elders in each of the farm enterprises, that constitute the farming systems? This is fundamental to understanding the potential impacts of

SustInAfrica on women, men and children. The baseline data will be collected through household interviews using a survey tool developed by SHA, that tracks both daily and seasonal activities.

Gender Analysis Framework: Ownership, Access and Control Profile

The access and control profile will assess who has access to, and control of, resources, services and decision making in each of the farm enterprises that constitute the farming systems. The data will be collected during the baseline, using a survey form developed by SHA. Additional questions will be developed after revieing the baseline data to understand any potential changes to access and control as a result of SustInAfrica. As an example: cotton, a cash crop, is generally considered a man's crop in much of Africa. Women are involved in field preparation, planting, weeding and particularly harvesting, but men control the income from the sale of cotton. Cowpeas (*Vigna unguiculate*) are generally a household food staple and under the control of women. How would intercropping cotton and cowpeas affect access and control of these crops? Would intercropped cowpeas remain under the control of women or become a defacto "man's crop"? It is important to note that ownership, access and control can be very different. Cattle, for example, are frequently owned by men and building a herd is often a prerequisite for a man to marry. Though women may not own the animals, they can access them, and the milk is almost invariably under the control of women, who dominate the traditional milk value chain in most of Africa.

Gender Analysis Framework: Analysis of factors and trends

WP5 will use secondary sources (national statistics, Ministries of Gender, UNICEF, UNIFEM, NGO reports) and key informant interviews, with gender researchers and women leaders to determine how activities, access and control patterns are shaped by structural, cultural, religious and attitudinal factors and how are these trends changing.
Relevant Ministries for women in each country:

- Burkina Faso: Ministère de la Femme, de la Solidarité nationale, et de la Famille https://www.action-sociale.gov.bf/
- Egypt: No Ministry of Women found
- Ghana: Ministry of Gender, Children and Social Protection https://www.mogcsp.gov.gh/
- Niger: Niger Ministère de la Promotion de la Femme et de la Protection de l'Enfance (Ministry for the Promotion of Women and the Protection of Children) http://www.promotionfemme.gouv.ne/
- Tunisia: Ministry of Women's Affairs [all publications are in Arabic] http://www.femmes.gov.tn

Workload of Women (Seasonal) / Female Energy Expenditure

Outputs/ technologies/ products/ practical solutions will only be adopted if they reduce workload or provide higher returns for the same workload. Women's workload is one of the factors that affect child nutritional status, with field nutrition surveys frequently reporting negative corelations between the amount of time the mother is away from their child and the child's nutritional status. WP5 will therefore assess the potential changes in women's workload / energy expenditure of SustInAfrica outputs. Successful outputs will:

- reduce women's labour and energy requirements
- spread the labour across the season to reduce labour peaks
- provide a higher return to family labour in terms of labour per unit of land or unit of output.

To access women's labour requirements the field trials will track the time spent on agricultural activities over the cropping season, disaggregated by gender, for each crop/ technology and the control plot (fig. 6).

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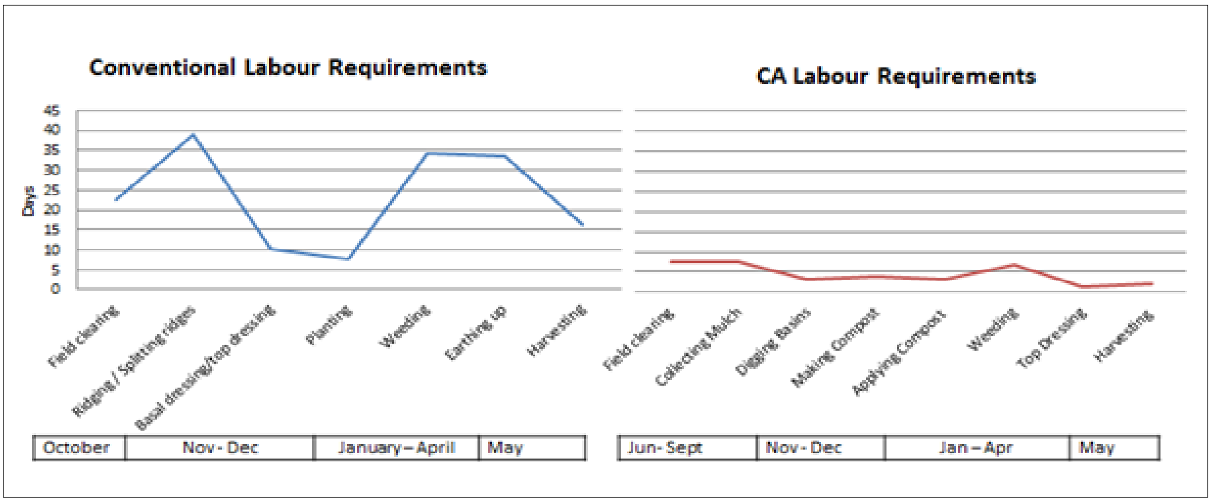

Figure 5: Example from Malawi: women's labour requirements for conventional agriculture v conservation agriculture (CA, minimum/ reduced tillage). The CA cropping season was longer, but the season peaks were much less pronounced, particularly during the start of the rains (Nov) when both agricultural and domestic workloads are at their greatest.

Potential impact on migrant pastoralist communities and indigenous communities who share common resources.

For centuries pastoralists in West African Sahel have practised seasonal transhumance, generally moving southward during the dry season to dry season grazing areas. The migrations were traditionally beneficial to both pastoralists and sedentary farmers, however these traditional relationships are under stress as dry season grazing areas are converted into irrigation schemes, insecurity creates no-go areas and unscrupulous politicians and insurgent groups promote inter-ethnic conflict. WP5 will review the sites chosen for the field trials against known transhumance patterns and local knowledge to ensure that SustInAfrica's work does not risk creating conflicts.

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5. Environment Metrics

In order for SustInAfrica to contribute to SDG 15: ensure the conservation, restoration, and sustainable use of ecosystem services, WP5 will use the **Common International Classification of Ecosystem Services (**CICES v5.1**),** https://cices.eu/**,** developed by the **European Environment Agency (EEA)** as the basis for assessing the potential impact of the outputs. CICES is preferred to FAOs classification of Ecosystem Services originally proposed for SustInAfrica as several of SustInAfrica's European collaborators are already using CICES. CICES differs slightly from FAOs classification of Ecosystem Services as it does not include Supporting Services as a separate category.

WP5 will assess the following services
- **Provisioning services**: food, raw materials, freshwater,
- **Regulating and Maintenance services**: air quality, carbon sequestration, moderation of extreme events, wastewater treatment, erosion prevention and soil fertility, pollination, biological control, regulation of water flow,
- **Cultural services**: recreational and mental and physical health, tourism, aesthetic appreciation and inspiration for culture, art and design, spiritual experience and sense of place.

Provisioning Services

These cover the provision of biotic and abiotic services. Biotic services include the husbandry and wild harvesting of plants, fungi, algae and animals for nutrition, fodder, fibre, energy and other raw materials, while abiotic services include freshwater. WP5 will assess the positive and negative impacts of SustInAfrica on the provision services.

Biotic

a. Cultivated terrestrial plants grown for nutritional purposes
b. Fibres and other materials from cultivated plants for direct use or processing (excluding genetic materials)
c. Cultivated plants grown as a source of energy
d. Animals reared for nutritional purposes
e. Fibres and other materials from reared animals for direct use or processing (excluding genetic materials).
f. Seeds, spores and other plant materials collected for maintaining or establishing a population.

Abiotic

a. Surface water for drinking
b. Surface water used as a material (non-drinking purposes)
c. Ground (and subsurface) water for drinking
d. Ground water (and subsurface) used as a material (non-drinking purposes)

These will be assessed using the following metrics:
- Crop Yields partitioned into food, seed, fodder, mulch and fuel.
- Livestock production: milk, meat, leather, manure
- Irrigation water balances from surface water and groundwater

Regulation & Maintenance

a. Control of erosion rates
b. Wind protection

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c. Pollination
d. Pest control (including invasive species)
e. Disease control
f. Decomposition and fixing processes and their effect on soil quality

These will be assessed using the following metrics: Erosion rates, Leaf Area Index and % mulch cover

Soil Analysis: Soil fertility is the foundation of all agricultural development and research and SustInAfrica will assess the standard soil physical and chemical parameters recommended by the Soil4Africa project with some additional indicators:

- Soil classification
- Soil Texture
- Bulk Density
- Macro nutrients: NPK
- Soil pH (H_2O or $CaCl_2$/KCl)
- Soil carbon and Soil Organic Matter (SOM)
- Soil Electrical Conductivity/ soil salinity
- Biological: biological activity/ soil respiration, Soil enzymes, decomposition rates

Hydrological cycle regulation: amount of surface water needed for irrigation soil humidity in crop systems

Wind protection: presence of trees in farming systems that form wind breaks.

Pollination: crop diversity disaggregated by wind and insect (animal) pollinated crops.

Pest control: Field data of damage to crops from invertebrate and vertebrate pests. Evidence of predators and hyper parasites in farming systems: insect traps, bird counts, presence of lizards, frogs, small mammalian insectivores/ carnivores in farming systems

Disease control: field data on incidence of plant diseases in crop systems.

Cultural

a. **Elements of living systems that have sacred or religious meaning.** recognition of crops or livestock important by local communities in terms of spiritual or symbolic meaning.
b. **Characteristics of living systems that are resonant in terms of culture or heritage.** Recognition of a crop or livestock as a cultural heritage by the local communities in terms of empiric knowledge and as a heritage to future generations.

WP5 will assess these as part of the baseline Farming Systems Analysis and through secondary data.

In addition to the CICE indicators WP5 will assess the potential impact of SustInAfrica outputs on the follow factors:
Insect Biodiversity. As SustInAfrica has a strong entomology component WP5 will use the entomology data to assess insect biodiversity as a proxy for biodiversity.

Diversification of Farming Systems: Self Help Africa promotes the diversification of farm enterprises in all projects to hedge against climatic and economic shocks, to improve household dietary diversity and, through crop rotation and intercropping, to maintain soil fertility and manage pests. WP5 will review the potential of SustInAfrica's outputs to create opportunities for farm diversification. WP5 will use data from the baseline farming system analysis, analysis of seasonal workloads, gross margins, yield and land equivalent ratios.

6. Assess Replicability

SustInAfrica aims to develop sustainable and resilient farming systems in West & North Africa by empowering smallholder farmers, small and medium-sized enterprises, and various government and non-governmental organizations in Ghana, Burkina Faso, Niger, Egypt, and Tunisia, to intensify food production and deliver ecosystem services in a sustainable and resilient manner. Transforming farming systems and currently applied agricultural practices toward more resilient ones requires the adoption of innovations that will induce changes in socio-economical aspects and behaviours and generating new pathways to changes. The focus of the project is on increasing production and responsible consumption (SDG12), therefore the possible trade-offs on achieving the other SDGs are crucial. Short and long-term impacts need to be understood, to avoid the undermining of the adaptation goals of SDG13 and SDGs 1, 2, 5 and 10.

Transformative actions in food systems are needed to contribute to SDGs. The approach of the project includes the joint identification and transfer of several typologies of innovations: soil, water, and plant health management strategies, together with the development of technologies and also business models and policy that could support farmers in their decision-making process. All those methods, technologies and solutions are meant to transform the local food systems in the Agro-Ecological Zones (AEZ) identified by the project. Most of the innovations were developed and tested in other contexts, where they proved to be sustainable and to respond to specific needs. The project partners are proposing the adoption of such innovations in different Agro-Ecological Zones (AEZ). Therefore, while the demonstration projects and the pilot actions bring research and innovation results to the users, the replicability analysis aims to ensure that such outputs could be widely adopted in different AEZs or even replicated in other areas widening the overall impact of the project.

The purpose of Task 5.2 is to ensure wide adoption of the identified project outcomes (both agricultural practices and technological solutions) previously validated as sustainable in task 5.1 and will build upon the same indicator set and frameworks to develop a methodological framework for the analysis of replicability (**D5.2.a: Develop a methodological framework for replicability analysis: Initial set of replicability indicators**). The analysis will monitor the implementation of the innovations in the AEZs and it will also identify the main issues that would require attention in the course of the demonstration projects or pilot actions, enabling partners and project to overcome possible stumbling blocks or constraints to a wider implementation (scaling up or transfer).

Farming systems are sustainable if they contribute to environmental, social, and economic co-benefits, such as food and nutrition security, generate employment, or provide income among other aspects. Furthermore, the sustainability of farming systems can be characterized by a set of underlying attributes inherent in each system. Lopez-Ridaura et al (2005) highlighted five core attributes, which refer to the functioning of a farming system itself – *productivity* and *stability* – and three related to the behaviour of the system when exposed to internal and external impacts – *reliability, resilience, and adaptability*. Productivity describes the efficiency of a system, while stability relates to the conservation of the resource base. Resilience, reliability, and adaptability describe the capability of a system to face perturbations in its functioning and within the environment. In the context of the AEZ, sustainability also refers to sustained agricultural productivity in the long term, while, at the same time, maintaining or increasing the underpinning ecosystem services that provision, support or regulate such productivity.

In the project 13 AEZ and 13 “core communities” (39 communities) will be considered, including all the stakeholders; consequently given the heterogeneity of agriculture and food systems, there is no one-size-fits-all solution, and contexts need be analysed and characterized bearing in mind and anticipating the possible changes induced by the innovative agroecological practices and technologies.

To be able to screen all innovative options provided by the project in a systematic way and to define which innovations, once adopted by the AEZ, are sustainable and replicable, we will follow the IFES Analytical Framework set by FAO (see Figure 7) as a guidance document (FAO 2014). It provides users with a conceptual framework to assess which factors make a system truly sustainable and which factors need to be considered when replicating such a system - be it a pilot project, a business innovation, or a research experiment. The analytical framework entails a set of leading questions and related features that help to analyse which factors need to be built into the "new" agricultural systems generated by the deployment of the proposed innovations to make them replicable and bring them to scale. The reported scheme for the analytical framework shows a general guidance that will be adapted and contextualized to our specific needs (AEZs and innovations) and the structure of the WPs.

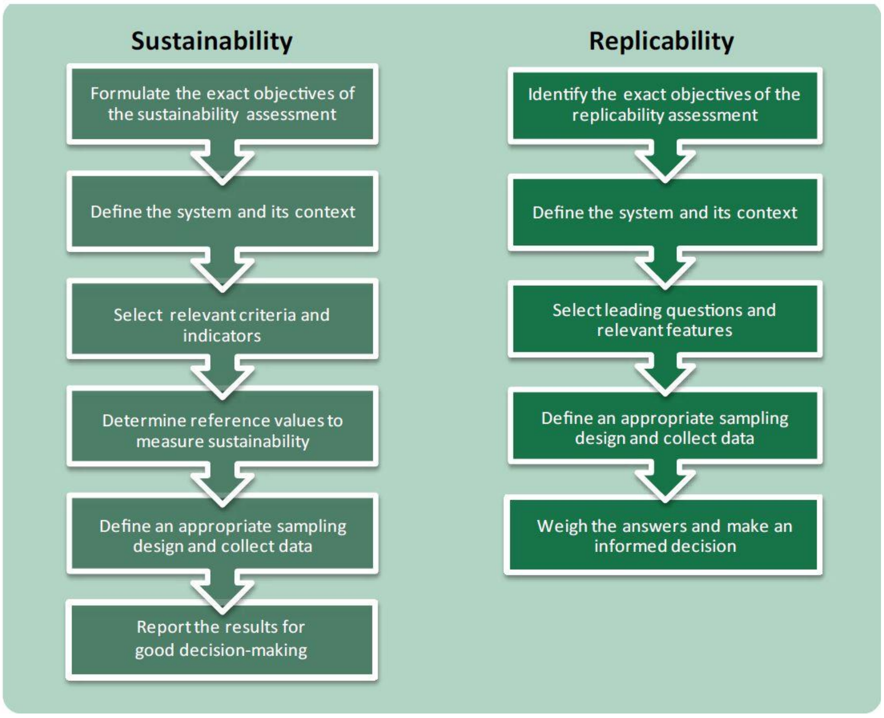

Figure 6: Steps for the implementation of a replicability analysis following a sustainability analysis (FAO, 2014)

The first phase of the replicability analytical framework aims to define the system and its context. For our project, this means that the AEZs (contexts) should be systematically described by collecting data from the areas of intervention, that describe their natural asset (soil quality, water availability and quality, biodiversity, etc.), the state of resources (water scarcity or depletions, soil erosion, wind erosion, etc.), the communities that live in the AEZs, the people that have a stake in agriculture and the structural characteristics of the farms and of the cropping systems. The next step is to select relevant criteria and indicators to perform a diagnosis of the system analysed, to determine reference values and serve as starting point for the evaluation of replication potential. The data collected, also via different stakeholders, will be systematized and easily accessible through Luke's Tiimeri workspace. CIHEAM will profit of such data to accomplish the description of AEZs and other project deliverables (Data Management Plan in WP7 Task7.4.b). In the present paragraph, we just mention the indicators that are useful to further detail our analysis because of future work.

To characterize the AEZs and the related cropping systems, as well as to track the impacts of implemented innovations also on the AEZs' structure, information about the structural characteristics of cropping systems are needed (Table 1). The "structure" of the AEZ derives from the structure of the field crops belonging to the area of land. The structure of a farm derives from the spatialization of crops and cultivation techniques and their change over time (cropping system). The structural

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characteristics will be used to describe the AEZ and will be referred at the AEZ level, but they need to be collected at the farm level or field level and then be aggregated for each AEZ.

Agro-environmental indicators		Acronym	Unit of measure	References
Structure of AEZ	Plot Size (Crop Field Size = patch area)	CFS	Ha	Calabrese, 2009; Migliorini e Vazzana, 2007
	Field density	FD	Number * ha^{-1}	Migliorini e Vazzana, 2007
	Duration of Rotation (average)	DCR	Number	Pacini et al., 2003
	Crop Rotation	CR	Crops*yrs^{-1}	Calabrese, 2009
	Crop diversity	CD	Number	Calabrese, 2009
	Permanent crop density (field)	PCD	Number * ha^{-1}	Calabrese, 2009; Caporali et al., 2003
	Herbaceous crop density	HCD	Number * ha^{-1}	Calabrese, 2009; Caporali et al., 2003

Table 3: Proposed indicators to describe the structure of AEZs.

In each AEZ one or more demonstration fields/plot will be activated, in that case, data about the following parameters should be collected using a mix of participatory methods: Total farm surface (Ha); Utilised Agricultural Area (UAA) (Ha); Crops per farm (n); Crop per field (n); Rotations for each field (number of crops*$year^{-1}$ and/or number of years in case of herbaceous crops); Cultivated varieties (number of different varieties per crop). Maps and cartographies and GIS can be of great support in describing AEZs and also the farming and cropping systems.

Besides such indicators, finalised to describe the structure of the agroecosystems of AEZ and the current way to achieve some essential indicators for each of the three sustainability pillars i.e. social, environmental and economic, it will be proposed to assess the baseline and track the changes induced by the project implementation in upcoming years (Table 2). Hence, we assess the sustainability compared to the baseline scenario. Indicators will be the impact (quantitative) or performance (process or qualitative) in nature. It needs to be understood that this selection is not exhaustive and might have to be complemented with other relevant criteria and indicators related to each specific case. Finally, potential for replication for new technologies/innovations or any combination thereof is assessed.

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Indicator	Metric (unit) & level (scale(s)	Description	Source(s)	How to collect this data
Crop Yield per AEZ	($kg*ha^{-1}$) Crop/field level	Assess the baseline for innovation in agro-ecological practices	FAO; SGD 2.4.1	Interviews with farmers in the course of WP1
Amount of yield losses from pests	($kg*ha^{-1}$) Crop/field level (per crop and AEZ)	Incidence of pest – proxy to demonstrate the effectiveness of using Insectamon for pest management strategy	CICES v 5.1 - Pest control (including invasive species) - 2.2.3.1	Interviews with farmers (1st assessment) and surveys (monitoring)
Share of cropland under integrated Pest management	(%) Crop/field level	To achieve a more comprehensive innovation potential	-	Interviews with farmers in the course of WP1
Increase in production from the adoption of NEW agro-ecological practices	(%) Farm-level/ AEZ level	To assess the baseline for innovation in agro-ecological practices	FAO; SGD 2.4.1	Interviews with farmers in the course of WP5
Increase in production from adoption innovations (INSECTAMON – BLUELEAF)	(%) Crop/field level/AEZ level	To assess the baseline for innovation in agro-ecological practices	FAO; SGD 2.4.1	Interviews with farmers in the course of WP1
Water use efficiency (WUE) – Crop yield per unit of water supplied	(kg/m^3) Crop level	To assess the baseline for innovation in agro-ecological practices	CICES v 5.1 4.2.1.2; Abi Saab et al. (2019)	Modelling and/or field measurements / surveys
Water Productivity (WP) – Crop yield per unit of water consumed (beneficially used by crop)	(kg/m^3) Crop level	To assess the baseline for innovation in agro-ecological practices	CICES v 5.1 4.2.1.2; Abi Saab et al. (2019)	Modelling and/or field measurements / surveys
Change in water-use efficiency (and water productivity) over time	(%) Crop level; AEZ	To assess the baseline for innovation in agro-ecological practices	FAO; SGD 6.4.1	Modelling/estimation
Level of water stress: Freshwater withdrawal as a proportion of available freshwater resources	(%) AEZ, regional	To assess the baseline for innovation in agro-ecological practices	FAO; SGD 6.4.2	Modelling/ SDG database [https://www.sdg.org/datasets]/estimation

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Water delivery performance	(%) AEZ, regional	To assess the baseline for innovation in agro-ecological practices	Malano, H. M., & Burton, M. (2001). Guidelines for benchmarking performance in the irrigation and drainage sector (No. 5). Food & Agriculture Org..	Surveys/Modelling/ estimation
Annual water supply	(-) AEZ, regional	To assess the baseline for innovation in agro-ecological practices	Malano, H. M., & Burton, M. (2001).	Modelling/estimation/existing databases
Pollutant loadings (fertilizer, manure)	(mg/l) AEZ, regional	To assess the baseline for innovation in agro-ecological practices	FAO – Integrated Food Energy system (2014)	Survey
Resource availability and efficiency of use	(-) AEZ, regional	Replicability and sustainability	FAO – Integrated Food Energy system (2014)	-
The proportion of agricultural area under productive and sustainable agriculture	(%) AEZ, Regional	Replicability and sustainability	SDG 2.4.1 and	Interviews & Survey/ SDG database [https://www.sdg.org/datasets]
No. of farmers applying NEW practices and innovations (INSECTAMON – BLUELEAF)	(Numerical value) AEZ	Replicability and sustainability	FAO – Integrated Food Energy system (2014)	Interviews & Survey
Good practices applied on farm to improve resilience	(Numerical value) AEZ	Replicability and sustainability	FAO – Integrated Food Energy system (2014)	Interviews & Survey
Food loss/increment index	($kg*ha^{-1}$) Crop, AEZ	Replicability and sustainability	SDG 12.3.1	Interviews & Survey
Time to recover from production loss (monetary or in terms of weight)	(years) Crop, Farm, AEZ	Replicability and sustainability	FAO – Integrated Food Energy system (2014)	Survey
Maximum of yield per average, wet and dry year	($kg*ha^{-1}$) Crop, AEZ	Replicability and sustainability	FAO – Integrated Food Energy system (2014)	Survey
Degree of integrated water resources management implementation	(0–100) AEZ, Regional	Replicability and sustainability	FAO; SGD 6.5.1	Survey/SDG database [https://www.sdg.org/datasets]
Proportion of youth and adults with	(%) AEZ, Regional	Replicability and sustainability	FAO; SGD 4.4.1	Survey/SDG database

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information and communications technology (ICT) skills, by type of skill				[https://www.sdg.org/datasets]
Value of production ($/ha, $/farm)	AEZ	Replicability and sustainability	SDG	Interviews & Survey
Benefit/Cost ratio	(-) Crop, Technology, AEZ	Replicability and sustainability	FAO – Integrated Food Energy system (2014)	Interviews & Survey
Economic viability (period for return of capital)	(years) Technology	Replicability and sustainability		Calculation
- % Increase in income of producers from adoption practices and innovations (INSECTAMON – BLUELEAF)	(% or Local currency/hectare) AEZ	Replicability and sustainability	FAO – Integrated Food Energy system (2014)	Interviews & Survey
Managers/ farmers satisfied with agricultural services as a percentage of all managers/farmers	(%) AEZ	Replicability and sustainability	FAO – Integrated Food Energy system (2014)	Interviews & Survey
Day of training provided	(days) AEZ	Replicability and sustainability	FAO – Integrated Food Energy system (2014)	Interviews & Survey

Table 4: List of indicators aiming to provide a baseline for monitoring the state of play of agricultural practices and, in coming years, the state of implementation of both technological and agroecological innovations.

Some basic definitions of selected indicators reported in Table 2 are described in more detail below, to facilitate data collection and elaboration (Cerda, 2017):

- **Crop Yield (kg*ha^{-1})** per crop per AEZ - It is the **average** production achieved per crop in each AEZ. This is very basic information and it is needed to assess the productivity of agricultural areas in the AEZs and to have a benchmark for any future improvement induced by the project actions. The definition of crop yield refers to the definition of actual yield, that is consistent in the most important literature on crop losses, and so is also accepted in this research: the actual yield is the site-specific yield achieved using the available resources and current practices (labour and inputs) of the farmer, generally affected by pests and diseases (Nutter et al., 1993; Savary et al., 2006; Savary and Willocquet, 2014). In this research, it is considered that each field crop has its actual yield.

- **Amount of yield losses from pests (kg*ha^{-1})** (per crop and AEZ) - The indicator can be used to characterise farms and AEZ. Crop loss is the reduction in quantity and/or quality of the crop yield (yield loss) due to biotic or abiotic factors, which can occur in the field (pre-harvest) or the storage (post-harvest) (Oerke, 2006). Such reductions are also known as crop damage (Savary et al., 2012). For others, crop loss also includes a reduction in value and/or financial returns due to yield loss (Nutter et al., 1993).

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- **Yield loss (kg*ha^{-1})** is the quantitative decrease of the crop yield caused by a single injury or by an injury profile. The yield loss is the difference between attainable yield and actual yield and can be expressed in terms of weight or volume or as relative yield loss (%) concerning the attainable yield (Nutter et al., 1993; Savary et al., 2006).

- **Attainable yield (kg*ha^{-1})** is the yield without the negative effects of yield-reducing factors (especially pests and diseases), limited only by yield defining factors (radiation, temperature, crop phenology, and physiology) and limiting factors (water and soil nutrients) (Zadoks and Schein, 1979; Rabbinge, 1993; Savary and Willocquet, 2014). Under this broad definition, we consider attainable yield as the site-specific yield achieved under the environmental conditions of the site and with the best available production techniques, to avoid biotic stress caused by pests (Nutter et al., 1993; Oerke et al., 1994). The definitions of attainable yield given by Nutter et al. (1993) and Oerke et al. (1994), have two important similitudes: both consider that attainable yield is site-specific and is achieved with the local production techniques, and both consider that it should be achieved in absence of pests. These definitions are considered the most suitable for the approaches and objectives of our project and of the innovations we are proposing that include BlueLeaf and InsectaMon. An attainable yield can involve high costs to control any pest or disease, and thus, would not be always the best economic yield; that is why this yield is considered to be theoretically independent of economic factors (Avelino et al., 2011). Therefore, other indicators have been introduced to track this aspect in time:
  - Value of production (Euro/ha, Euro/farm)
  - % Increase in income (Euro) of producers from adoption practices and innovations (INSECTAMON – BlueLeaf).
- **Water use efficiency (WUE)** - WUE is usually calculated based on the grain yield or total biomass produced per unit of water supplied to a field (including both precipitation and irrigation). WUE assesses the adequacy, equity, and efficiency of water utilization in a field. Water efficiency in irrigated/rainfed agriculture is calculated as the agricultural value added per agricultural (net) water withdrawn, expressed in USD/m^3.

- **Water productivity (WP)** - represents the yield or biomass produced per unit of water effectively consumed by crop in a field – which refers to crop evapotranspiration. WP assesses the adequacy of applied agronomic practices (including the use of different cultivars) and it is directly linked with the crop response to the amount of water used.

- **Change in water-use efficiency and water productivity over time (%)** - The change in the ratio of the value added to the volume of water use, over time.

- **Freshwater withdrawal as a proportion of available freshwater resources (%)** – Ratio between total freshwater withdrawn by all major sectors and total renewable freshwater resources, after taking into account environmental flow requirements.

- **Water delivery performance (%)** - Water delivery performance is generally defined as the amount of actual water. delivered by the system compared to the target amount.

- **Annual water supply** – It is the ratio between total annual volume of water supply and total annual volume of crop water demand.

- **The proportion of agricultural area under productive and sustainable agriculture (%)** - This indicator is defined as the percentage of "agricultural area" that is "area under productive and sustainable agriculture".

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- **Time to recover from production loss (monetary or in terms of weight)** - Time to recover from production loss from catastrophic events such as crop loss, forest fire or flooding in years.

- **Maximum of yield per average, wet and dry year** - Minimum, maximum and average yield in driest years.

- **Degree of integrated water resources management implementation (0–100)**: a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

- **Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill (%)** - Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill.

- **Pollutant loadings (fertilizer, manure)** - Nitrate (or phosphorus) concentration in water: the proportion of surface water and groundwater above a national threshold value of nitrate concentration (NO_3 mg/l) or phosphorus (P total mg/l).

- **Good practices applied on farm to improve resilience** - Number of good practices applied on farm to improve resilience.

- **Benefit/cost ratio -** A benefit-cost ratio (BCR) is an indicator showing the relationship between the relative costs and benefits of a proposed project, expressed in monetary or qualitative terms.

- **Value of production** - Value of production measures production in monetary terms at the farm gate level at the time they are produced. It can be compiled by multiplying gross production in physical terms by output prices at farm gate. Value of gross production is provided in both current and constant terms and is expressed in Euro and Standard Local Currency (SLC).

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7. Economic Assessment

Theoretical basis for assessments

Once the WP5 has completed the screening the SustInAfrica outputs/ technologies/ products/ practical solutions the task of WP5 will be to decide on the appropriate exploitation routes. The exploitation routes will be primarily either as commercial products or as public goods to be distributed through appropriate channels.

To assess the commercial potential of the outputs/ technologies/ products/ practical solutions, as well as their impact on the livelihoods and nutrition of farmers and SMEs WP5 will use standard metrics widely used in investment economics and Value Chain Analysis. As far as possible metrics have been selected that can also be used to assess several criteria. The concept of 'value chain' was developed by Porter (1985) to describe the full set of activities required to bring a valuable product or service from conception, through the different phases of production, distribution to consumers and final disposal after use. Value chain analysis, explained below, is a robust methodology for exploring various aspects of the economy-environment interface and also provides a framework for coherent and integrated response by industry as well as policy makers, through its focus on linkage within the different stages and actors in a chain (D. Kristina and E. Paul, 2005).

Project Appraisal

To assess the investment potential WP5 will conduct project appraisals for the outputs/ technologies/ products/ practical solutions. WP5 will require the following metrics.

Gross Margin Analysis

Gross Margins for smallholder agriculture traditionally do not account for family labour, capital expenditure or depreciation and is simply: Total variable costs – total cash revenue.

The field trials will record the costs of inputs, labour hours and costs and the yield, the average price for the harvest and the total revenue to calculate the Gross Margins. An electronic tool will be developed to track Costs and Revenues on the tablets.

Returns to Family Labour

This is a measure of the economic returns from investing time and labour in a farm enterprise, recorded as the net income per person hour (or day). Returns to family Labour enables enterprises to be compared based on the amount of labour required and the opportunity costs of time spent on the enterprise. This is critical indictor for smallholder farmers and is important for predicting the adoption of SustInAfrica research output in labour-scarce households. The field trials will record the time spent on field operations by the farmer and her family, disaggregated by gender.

Project Costs and Benefits

Using the data from the Gross Margin Analysis the with and without project (SustInAfrica research output v traditional practices) the project effect can be calculated.

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	Lira district			
Labor costs	Traditional	Low input	High input	Conservation tillage
Land clearing	56,038	50,038	46,038	40,000
First ploughing	35,600	35,800	35,856	0
Second ploughing	36,167	35,600	38,650	0
Herbicide use	0	5,600	7,450	6,000
Digging holes, add fertilizer and planting	25,000	32,800	33,400	60,000
1st weeding / Spot weeding	52,500	40,250	45,000	45,600
Application of fertilizer	0	0	30,000	0
2nd weeding	0	50,000	50,234	42,500
Pesticide application	0	12,340	24,000	6,000
Harvesting	8,000	12,000	15,600	10,000
Transporting home/ store	6,000	16,000	24,800	7,500
Drying	8,500	12,000	15,000	12,000
Shelling	6,000	9,000	20,800	4,500
Cleaning, sorting Grading, bagging	5,600	11,580	22,460	20,000
Total Labor Cost	**239,405**	**323,008**	**409,288**	**254,100**
Costs of inputs				
Hired land	0	66,900	74,500	73,705
Seed	0	40,000	40,000	43,560
Fertilizers	0	0	254,600	120,000
Herbicides	0	27,840	28,450	25,000
Inorganic insecticides	0	15,600	18,600	15,800
Bags	4,500	10,000	15,640	15,000
Total Input cost	**4,500**	**160,340**	**431,790**	**293,065**
Total Variable cost	**243,905**	**483,348**	**841,078**	**547,165**
Total Yield (TY)	524	956.87	2,456	1,456
Average price (Ug shs/kg)	350	450	450	450
Total Revenue (TR)	183,400	430,592	1,105,200	655,200
Gross margin (TR-TVC)	**-60,505**	**-52,757**	**264,122**	**108,035**
Benefit-cost ratio (TR/TVC)	0.75	0.89	1.31	1.20
Returns to investment based on total cost of production (TVC/TY)	465.47	505.13	342.46	375.80
Marginal returns on investment (Unit price-Unit cost of production)	(115.47)	(55.13)	107.54	74.20

Figure 7: Example of Gross Margin Analysis for maize in Lira District, Uganda, under three production practices per acre per season, showing the metrics that need to be recorded at the field level

Net Present Value (NPV)

The longer the wait for a return on an investment the less valuable the future returns are. Returns from long term investments therefore need to be discounted to provide a realistic estimate of the current value, the NPV. The NPV will be essential to analyse the profitability of a projected investment for example a technology developed as a result of the project.

Benefit: cost ratio

The Benefit: cost ratio is calculated for a range of discount rates

Internal Rate of Return

The NPV for costs and benefits are compared over a range of discount rates to identify the rate above which the investment is no longer viable (Fig. 8). In addition, the IRR will be essential to analyse the profitability of a projected investment developed as a result of the project.

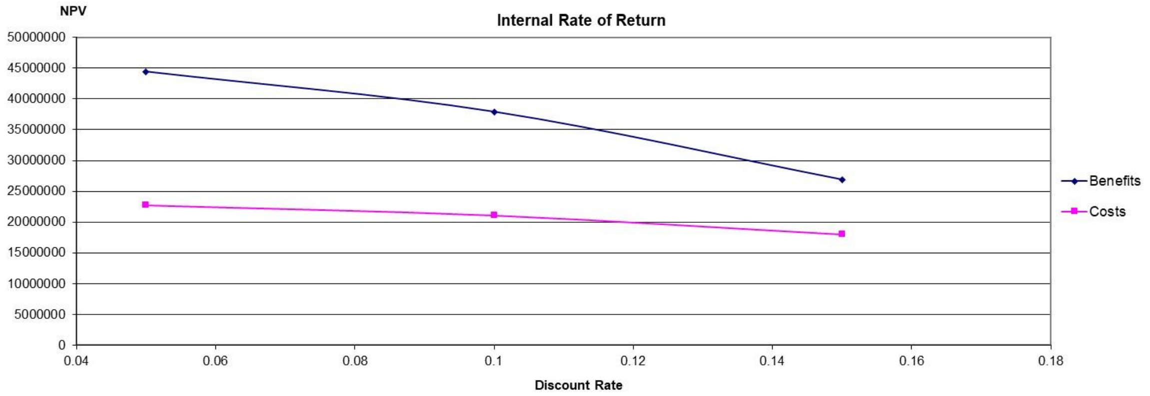

Figure 8: example of the internal rate of return at a range of discount rates

Risk Benefit Analysis

Description: Show a higher ratio of benefits to risks than that of existing technologies.

Value Chain Analysis

Value chain analysis (VCA) is a process that identifies **primary** and **support activities** that **add value** to a final product and then analyses these activities to **reduce costs** or **increase differentiation** (Fig. 9). VCA is undertaken in order to design interventions that will increase the value of the whole value chain (as well as to enable a specific target group to participate in that value chain) and seeks to establish the gross margins earned by each value chain actor carrying out a specific function within the value chain ,the flow of information as well as finance both up and downstream. VCA normally defines value in financial terms Value is a broader term. Price is what you will pay for something. Value is the good or service pays you. This can also be in financial, emotional, physical or even nutritional terms (Springer-Heinze, 2018).

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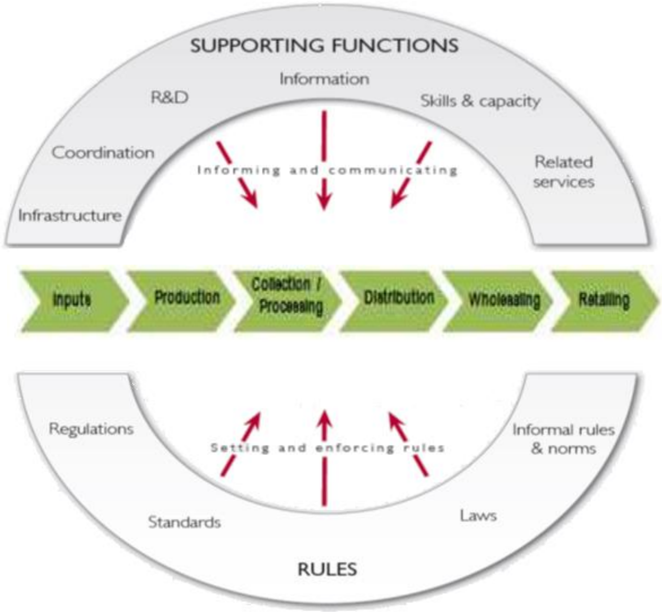

Figure 9: Value Chain Analysis

To start VCA for the SustInAfrica's products WP5 will required data on the Business Enabling Environment and support services including for example prevailing regulations, standards and laws.

Availability of Business support services

List/ summary of formal and informal Financial services, BDS, R&D as an indication of the support available locally to commercialise the technologies. This should be collected at the baseline through Interviews with farmers and Chambers of Commerce.

Investment climate

Secondary data like the WBs annual Ease of doing business, Financial services deepening reports, Business survival rates, Country stats. And the Global Impact Investment Network will provide an initial Indication of available investment opportunities, level of appetite and availability of capital to be invested on plausible ventures or business cases. It will also provide information on the potential to commercialise the technologies at an early stage and scale.

Macro-economic data

Secondary data on inflation, cost of living, food basket from the World Bank, National Statistics Agencies and Central Banks and the Trading Economics website https://tradingeconomics.com/ will provide an indication of potential commercialise the technologies

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Annex 1: Potential Additional Metrics

These are additional metrics that were not mentioned in the proposal or that WP5 considers "nice to have" rather than "must have".

Improve access and income for those with physical disabilities

In addition to gender equality SustInAfrica could consider other equality issues. A significant proportion of the rural population in Africa suffer from physical disabilities as a result of poor nutrition, high disease prevalence and poor healthcare facilities in rural areas and farm-related accidents.

SustInAfrica was not designed to address the needs of disabled farmers and so the outputs may not make the lives of disabled farmers easier, however it may be possible to adjust the research to take into account the needs of disabled farmers. To assess disability needs WP5 proposes the following metrics.

The Washington Group on disability statistics (WG) was formed as a United Nations Statistical Commission City Group whose main purpose is the promotion and coordination of international cooperation in generating statistics on disability suitable for censuses and national surveys. Its major objective is to provide basic information on disability that is comparable worldwide.

1.Washington Group on Disability Statistics website https://www.wg.lldev.co.uk
2. WG Short Set on Functioning (WG-SS) https://www.wg.lldev.co.uk/question-sets/wg-short-set-on-functioning-wg-ss/
3. WG Extended Set on Functioning (WG-ES) https://www.wg.lldev.co.uk/question-sets/wg-extended-set-on-functioning-wg-es/
4. WG Short Set on Functioning - Enhanced (WG-SS Enhanced) https://www.wg.lldev.co.uk/question-sets/wg-short-set-enhanced-on-functioning-wg-ss-enhanced/
5. WG/UNICEF Child Functioning Module (CFM) https://www.wg.lldev.co.uk/question-sets/wgunicefchild-functioning-module-cfm/

Data required: 1. Do you have difficulty seeing, even if wearing glasses?
2. Do you have difficulty hearing, even if using a hearing aid?
3. Do you have difficulty walking or climbing steps?
4. Do you have difficulty remembering or concentrating?
5. Do you have difficulty (with self-care such as) washing all over or dressing?
6 Using your usual language, do you have difficulty communicating (for example understanding or being understood by others)?

Each question has four response categories, which are read after each question. 1. No, no difficulty 2. Yes, some difficulty 3. Yes, a lot of difficulty 4. Cannot do it at all It is important to ask about the degree of difficulty for two

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Annex 2: Bibliography

Abi Saab, M.T.; Houssemeddine Sellami, M.; Giorio, P.; Basile, A.; Bonfante, A.; Rouphael, Y.; Fahed, S.; Jomaa, I.; Stephan, C.; Kabalan, R.; Massaad, R.; Todorovic, M.; Albrizio, R. (2019). Assessing the Potential of Cereal Production Systems to Adapt to Contrasting Weather Conditions in the Mediterranean Region. *Agronomy*, *9*, 393.

Andrew et al (2012). Dimension of sustainable value chain: implication for value chain analysis. *Supply Chain Management: An International Journal*. Vol. 17, Issue 6, pp. 575-581

Asian Development Bank. (2006). *Gender checklist: Agriculture*. 1–54. https://www.adb.org/sites/default/files/publication/28723/agri2.pdf

Avelino, J., Ten Hoopen, M., De Clerck, F., (2011). *Ecological Mechanisms for Pest and Disease Control in Coffee and Cacao Agroecosystems of the Neotropics*. In: Rapidel, B., F, D., JF, L.C., J, B. (Eds.), Ecosystem Services from Agriculture and Agroforestry Measurement and Payment. Earthscan, pp. 91-117.

Bhutta, Z. A., Das, J. K., Rizvi, A., Gaffey, M. F., Walker, N., Horton, S., Webb, P., Lartey, A., & Black, R. E. (2013). Evidence-based interventions for improvement of maternal and child nutrition: What can be done and at what cost? *The Lancet*, *382*(9890), 452–477. https://doi.org/10.1016/S0140-6736(13)60996-4

Burpee, G., B.S. Janet & A. Schmidt. 2015. Preparing smallholder farm families to adapt to climate change: Pocket Guide 3; Managing water resources. Catholic Relief Services: Baltimore, MD, USA.

Calabrese J., (2009). Capitolo 5. La biodiversità: applicazione delle procedure d’analisi. In: Indicatori di Biodiversità per la sostenibilità in Agricoltura – in Monografia Linee guida, strumenti e metodi per la valutazione della qualità degli agro ecosistemi, Caporali F. (coordinatore), Benedetti A., Calabrese J., Campiglia E., Di Felice V., Lazzerini G., Mancinelli R., Mocali S., Vazzana C., ISPRA - Istituto Superiore per la Protezione e la Ricerca Ambientale (vol.47/2008) pagg. 209-262. ISBN 978-88-448-0337-7.

Caporali F., Mancinelli R., Campiglia E., (2003). Indicators of cropping system diversity in organic and conventional farm in central Italy. *International Journal of Agricultural Sustainability* 1: 67-72.

CARE. (2018). CARE Guidance Note Gender Equality and Women’s Voice. February, 1–38.

CARE International Secretariat. (2019). Gender Equality and Women’s Voice Guidance Note. May.

Casas, N. M. (2017). Crop Weather and Climate Vulnerability Profiles (1st ed.; P. Wagstaff, ed.). Concern Worldwide, Dublin.

Cerda R. (2017). Assessment of yield and economic losses caused by pests and diseases in a range of management strategies and production situations in coffee agroecosystems. Life Sciences [q-bio]. Institut National d’Etudes Supérieures Agronomiques de Montpellier. English. https://hal.inrae.fr/tel-02784928/document

Common International Classification of Ecosystem Services (CICES v5.1) (2020) European Environment Agency (EEA) available: https://cices.eu/ [accessed 26 November 2020]

CIDSE ‘Climate-Smart Agriculture’: the Emperor’s new clothes? Brussels, October 2014

DHS (2020) The Demographic Health Surveys Program, available: https://dhsprogram.com/ [accessed 26 November 2020]

Food and Agriculture Organisation (FAO) (2013) Climate Smart Agriculture – Sourcebook, available: http://www.fao.org/3/i3325e/i3325e.pdf [accessed 26 November 2020]

FAO (2014) Evidence-based Assessment of the Sustainability and Replicability of Integrated Food Energy Systems Sourcebook, available: http://www.fao.org/3/a-i3669e.pdf

FAO Climate Smart Agriculture Sourcebook, Rome 2013.

FAO, IFAD and World Bank (2009) Gender in Agriculture - Sourcebook

FAO, IFAD, UNICEF, WFP, & WHO. (2020). The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. In *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N° 861924

Fontana, M., Paciello, C., & Villard, S. de. (2019). Gender dimensions of agricultural and rural employment : Differentiated pathways out of poverty Status , trends and gaps and rural employment

FSIN. (2020). *GLOBAL REPORT ON FOOD CRISES: Acute food insecurity and malnutrition forecasts for 2020.* 240. https://www.wfp.org/publications/2020-global-report-food-crises

Gereffi, G., Humphrey, J. and Strugeon, T. (2005), "The governance of global value chains", Review of International Political Economy, Vol. 12 No. 1, pp. 78-104.

Gillespie, S., Harris, J., and Kadiyala, S. (2012). The Agriculture-Nutrition Disconnect in India, What Do We Know? IFPRI Discussion Paper 01187

Govereh, J. and Jayne, T. (2003), Cash-cropping and food crop production: synergies or tradeoffs, *Agricultural Economics*, Vol. 28 No. 1, pp. 39-50.

Haddad, L. (2000). A conceptual framework for assessing agriculture-nutrition linkages. *Food and Nutrition Bulletin*, *21*(4), 367–373. https://doi.org/10.1177/156482650002100405

Hansen MT, Birkinshaw J. (2007), The innovation value chain. *Harv Bus Rev*. Jun; 85(6):121-30, 142.

Hawkes, C. and Ruel, M.T. (2011), Value chains for nutrition, 2020 Conference Paper No. 4, prepared for the IFPRI 2020 International Conference, "Leveraging Agriculture for Improving Nutrition and Health", New Delhi, February 10-12.

Hellin, J. and Meijer, M. (2006) Guidelines for value chain analysis, Food and Agriculture Organization.

Henson, S., Jaffee, S., Cranfield, J., Blanond, J. and Siegel, P. (2008), Linking African smallholders to high-value markets: practitioner perspectives on benefits, constraints and interventions, *Policy Research Working Paper No*. 4573, World Bank, Washington, DC.

Humphrey, J. (2005), Shaping Value Chains for Development: Global Value Chains in Agribusiness, Deutsche Gesellshaft fur International Zusammenarbeit (GIZ), Exchborn.

International Food Policy Research Institute (IFPRI). (2019). SYNOPSIS- 2019 Global Food Policy Report. March 2019. http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/130207

International Food Policy Research Institute. (2019). *Gobal Hunger Index*. *October*, 1–47.

International Fund for Agriculture and Development (IFAD) (2009), "Sharing and documenting good practices in value chain development", Writeshop report, Writeshop, IFAD Asia and the Pacific Division, November

Joy, E. J. M., Stein, A. J., Young, S. D., Ander, E. L., Watts, M. J., & Broadley, M. R. (2015). Zinc-enriched fertilisers as a potential public health intervention in Africa. *Plant and Soil*, *389*(1–2), 1–24. https://doi.org/10.1007/s11104-015-2430-8

Kaplinsky, R. and Morris, M. (2003) A Handbook for Value Chain Research, International Development Research Centre (IDRC), Canada.

Kristina, D. and Paul, E. (2005). Combining economic and environmental dimensions: Value chain analysis of UK iron and steel flows. Ecological Economics 58 pp. 507-519

Kumar, N. Harris, J. and Rawat, R. (2015). If they grow it, will they eat and grow? Evidence from Zambia on agricultural diversity and child undernutrition. *The Journal of Development Studies.* Special Issue: Farm-level Pathways to Improved Nutritional Status. 51(8): 1060 - 1077. http://dx.doi.org/10.1080/00220388.2015.1018901

Lee, J., Gereffi, G. and Barrientos, S. (2011) Global value chains, upgrading and poverty reduction, Capturing the Gains Briefing Note 3, University of Manchester.

López-Ridaura, S., Keulen, H. V., Ittersum, M. K. van, & Leffelaar, P. A. (2005). Multiscale Methodological Framework to Derive Criteria and Indicators for Sustainability Evaluation of Peasant Natural Resource Management Systems. Environment, Development and Sustainability, 7 1, 51–69.

Lundy, M., Ostertag, C. and Best, R. (2002). Value adding, agro-enterprise and poverty reduction: a territorial approach for rural business development, Rural Agro-Enterprise Development Project Paper, CIAT, Cali.

Lusby, F. (2007). Value Chain Program Design: Promoting Market-Based Solutions for MSME and Industry Competitiveness, USAID, Washington, DC.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 861924

Manfre, C., Rubin, D., & Nordehn, C. (2017). Assessing how agricultural technologies can change gender dynamics and food security: Part three. *USAID*, *October*, available: http://ingenaes.illinois.edu/wp-content/uploads/Part-Three-Share-Final-10_17.pdf
Marshak, A., Young, H. and Radday, A. (2012-2015) Water, Livestock, and Malnutrition. Findings from an Impact Assessment of Community Resilience to Acute Malnutrition Programming in the Dar Sila Region of Eastern Chad, 2012-2015. Feinstein International Center, December
Migliorini P., Vazzana C., (2007). Biodiversity Indicators for sustainability evaluation of conventional and organic agro-ecosystems. Italian journal of agronomy, 2: 105-110.
Ministère de la Femme, de la Solidarité nationale, et de la Famille, Burkina Faso (2020) Ministère de la Femme, de la Solidarité nationale, et de la Famille, available: https://www.action-sociale.gov.bf/ [accessed 10 November 2020]
Ministère de la Promotion de la Femme et de la Protection de l'Enfance, Niger (2020) Ministère de la Promotion de la Femme et de la Protection de l'Enfance, Niger, available: http://www.promotionfemme.gouv.ne/ [accessed 10 November 2020]
Ministry of Gender, Children and Social Protection, Ghana (2020) Ministry of Gender, Children and Social Protection, Republic of Ghana, available: https://www.mogcsp.gov.gh/ [accessed 10 November 2020]
Ministry of Women's Affairs, Tunisia (2020) available: http://www.femmes.gov.tn/ar/%d8%a8%d8%b1%d8%a7%d9%85%d8%ac-%d9%88%d9%85%d8%b4%d8%a7%d8%b1%d9%8a%d8%b9-%d9%82%d8%b7%d8%a7%d8%b9-%d8%a7%d9%84%d9%85%d8%b1%d8%a3%d8%a9/ [accessed 10 November 2020] [Arabic]
Moodley, L., Kuyoro, M., Holt, T., Leke, A., Madgavkar, A., Krishnan, M. F. A. (2019). *The power of parity | The Economist.* November, available: http://www.economist.com/news/finance-and-economics/21667949-world-would-be-much-richer-place-if-more-women-had-paying-jobs-power
Nutter, F.W., Teng, P.S., Royer, M.H., (1993). Terms and Concepts for Yield, Crop Loss, and Disease Thresholds. Plant Disease 77, 211-216.
Oerke, E.C., (2006). Crop losses to pests. Journal of Agricultural Science 144, 31-43.
Oerke, E.C., Dehne, H.W., Schonbeck, F., Weber, A., (1994). Crop Production and Crop Protection. Estimated losses in major food and cash crops. Elsevier, Amsterdan, The Netherlands.
Pacini G.C., Wossink A., Giesen G., Vazzana C., Huirne R., (2003). Evaluation of sustainability of organic, integrated and conventional farming systems: a farm and field scale analysis. Agriculture, Ecosystems and Environment 95: 273-288.
Pangaribowo, Evita Hanie; Gerber, Nicolas; Torero, Maximo (2013). Food and nutrition security indicators: A review, *ZEF Working Paper Series*, No. 108, University of Bonn, Center for Development Research (ZEF), Bonn
Porter, M. (1985) Competitive Advantage, New York: The Free Press.
Rabbinge, R., (1993). The ecological background of food production. In: Chadwick, D.J., Marsh, J. (Eds.), Crop protection and sustainable agriculture. JOHN WILEY & SONS, pp. 2-29.
Pimbert, M. (2015). Agroecology as an alternative vision to conventional development and climate-smart agriculture. Development (Basingstoke), 58(2–3), 286–298. https://doi.org/10.1057/s41301-016-0013-5
Ricketts, K. D. (2014). Value Chain approaches to development. Journal of Agribusiness in Development and Emerging Economies, Vol. 4 Issue 1 pp. 2-22
Ruel, M. T., & Alderman, H. (2013). Nutrition-sensitive interventions and programmes: How can they help to accelerate progress in improving maternal and child nutrition? *The Lancet*, *382*(9891), 536–551. https://doi.org/10.1016/S0140-6736(13)60843-0
Ruel, M. T., Quisumbing, A. R., & Balagamwala, M. (2018). Nutrition-sensitive agriculture: What have we learned so far? *Global Food Security*, *17*(September 2017), 128–153. https://doi.org/10.1016/j.gfs.2018.01.002

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 861924

Savary, S., Ficke, A., Aubertot, J.-N., Hollier, C., (2012). Crop losses due to diseases and their implications for global food production losses and food security. Food Security 4, 519-537.

Savary, S., Teng, P.S., Willocquet, L., Nutter, F., (2006). Quantification and Modeling of Crop Losses: A Review of Purposes. Annu. Rev. Phytopathol. 44, 89-112.

Savary, S., Willocquet, L., (2014). Simulation Modeling in Botanical Epidemiology and Crop Loss Analysis. The Plant Health Instructor, 173 p.

Shekar, M. (2005). Nutrition and income poverty. World Bank

Simpson, Brent M. 2016. Preparing smallholder farm families to adapt to climate change. Pocket Guide 1: Extension practice for agricultural adaptation. Catholic Relief Services: Baltimore, MD, USA.

Singh, S. (2007) Organic cotton supply and small producers: governance, participation and strategies, *Economic and Political Weekly*, 41(52), 5359-5366.

Springer-Heinze, A. (2018). ValueLinks 2.0. Manual on Sustainable Value Chain Development, GIZ Eschborn, 2 volumes

United Nations Children's Fund (UNICEF) (2020) Research and Reports, available: https://www.unicef.org/research-and-reports [accessed 16 November 2020]

United Nations Department of Economics and Social Affairs (UNDESA) (2019) World Population Prospects, available: https://population.un.org/wpp/ [accessed 26 November 2020]

United Nations Entity for Gender Equality and the Empowerment of Women (UN WOMEN) (2020) UN Women's Data Centre, *Women Count*, available: https://data.unwomen.org/ [accessed 26 November 2020]

United Nations International Development Organization (UNIDO) (2011). Pro-Poor Value Chain Development: 25 Guiding Questions for Designing and Implementing Agroindustry Projects, United Nations International Development Organization, Vienna.

Manfre, C., Rubin, D., & Nordehn, C. (2017). Assessing How Agricultural Technologies can Change Gender Dynamics and Food Security Outcomes, USAID INGENAES.

Von Grebmer, K., Bernstein, J., Patterson, F., Wiemers, M., Ní Chéilleachair, R., Foley, C., Gitter, S., Ekstrom, K., and Fritschel, H. (2019) Global Hunger Index, The Challenge of Hunger and Climate Change, Dublin/Bonn, October, available: https://reliefweb.int/sites/reliefweb.int/files/resources/2019%20Global%20Hunger%20Index.pdf [accessed 26 November 2020]

Wellesley, L., Eis, J., Marijs, C., Vexler, C., Waites, F., & Benton, T. G. (2020). *Chatham House Report The Business Case for Investment in Nutrition*.

WFP (2015) Meta Data for the Food Consumption Score (FCS) Indicator, available: https://www.wfp.org/publications/meta-data-food-consumption-score-fcs-indicator#:~:text=The%20%E2%80%9CFood%20consumption%20score%E2%80%9D%20(,comprise%20the%20food%20consumption%20score [accessed 26 November 2020]

Williams, S., Seed, J., & Mwau, A. (1994). *The Oxfam Gender Training Manual*. https://doi.org/10.3362/9780855988098

Zadoks, J.C., Schein, R.D., (1979). *Epidemiology and plant disease management*. Oxford University Press Inc., New York.

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