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

Deliverable D5.6
Technology scores (readiness) 1 - Requirement D40

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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. A list of Socioeconomic and environmental screening metrics was submitted in 2020 (Deliverable D5.1) and revised in D5.3. This report is an initial assessment of the technologies against the social, economic and environmental screening metrics. The report was updated with information on the 2023 season of crop trials at the Bari Annual meeting (Sept 2023). At this stage of the project there is limited field trial data as the West African countries will be harvesting in October 2023, so the initial screen has largely been based on the findings of the baseline surveys and interviews with the investigators. The Replicability and Scaling Readiness screen results have not been included in this report due to the limited data available but will be included in the next screening round. The project has not yet reached the stage where a decision on the appropriate exploitation routes commercialisation can be made for some of the technologies.

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

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List of abbreviations and acronyms

AEZ	Agro-ecological zone
AI	Artificial Intelligence
FAW	Fall Armyworm, *Spodoptera frugiperda*
Fe	Iron
FMNR	Farmer Managed Natural Regeneration
HS	Hyperspectral
IP	Intellectual Property
IPCC6	International Panel on Climate Change report 6
IR	Infrared
IVR	Interactive Voice Response
MIAE	Monitoring, Impact Assessment and Evaluation System
MoFA	Ministry of Food and Agriculture
MS	Multispectral
NIR	Near-infrared
PoC	Proof of Concept
RGB	Red-green-blue
SDG	Sustainable Development Goals
SMS	Short Message Service
SPAD	Soil Plant Analysis Development
SSA	Sub-Saharan Africa
SustInAfrica	Sustainable intensification of food production through resilient farming systems in West & North Africa
RCT	Randomised Control Trial
UAV	Unmanned aerial vehicle (drone)
UV	Ultraviolet
USA	United States of America
WP	Work Package
Zn	Zinc

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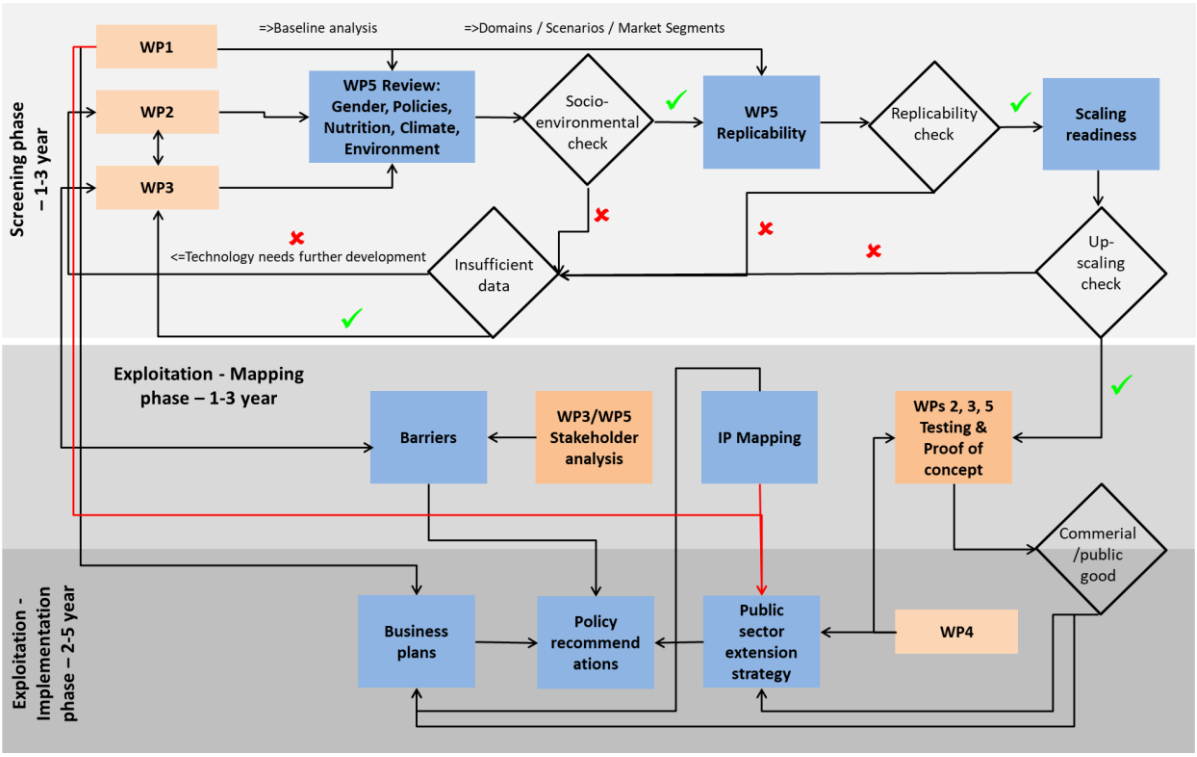
1. Introduction

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, the potential for replicability and scaling and the appropriate exploitation strategies.



SustInAfrica Technology Development and Screening Process (Monitoring, Impact Assessment and Evaluation System, MIAE)

This report is an initial assessment of the technologies against the social, economic and environmental screening metrics submitted in 2020 (Deliverable D5.1) and revised in D5.3 and represents the stage "socio-environmental check" highlighted in the flow chart. This screening stage is intended to confirm that the technologies and approaches will not have a negative impact on household nutrition, household labour requirements, women's workloads and access and control over household and community resources and the environment. This screening stage has also checked the potential resilience of the technologies and crops to predicted changes to climate, using IPCC6 data.

At this stage of the project there is limited field trial data, so the initial screen has largely been based on the findings of the baseline surveys and interviews with the investigators. as a result, the initial screening checks for most of the technologies are reported as "insufficient data."

The Replicability and Scaling Readiness screen results will be provided once the "socio-environmental check" stage has been completed.

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List of Technologies

WP2 technologies

Bluleaf

Bluleaf® is a smartphone app for irrigation water management. The app uses crop data, data from weather stations and soil sensors to determine how much water is required at each crop grow stage, how much has been provided by rainfall and how much supplemental irrigation is required. Irrigation can be managed from a smartphone and can be integrated with automatic valves and fertigation. The app can manage irrigation for multiple crops and plots on a farm. Bluleaf can reduce water uses and costs for farmers. BluLeaf requires access to meteorological data, which has proved to be challenging in several countries. Good quality automated weather stations are not available in-country and Importing weather stations is expensive and complicated. The initial suppliers were unwilling to supply directly to the countries and the contract has had to be retendered.

Farmerline®/ Mergdata®

Farmerline runs an online platform, Mergdata, that provides a wide range of integrated services. Farmerline can provide interactive extension and market advice to farmers across media: Interactive Voice Response (IVR) Systems in local languages, videos, as well as text. The system works on affordable phones as well as smartphones. The project will use Farmerline to deliver training to farmers once the technologies have been finalised. Currently the project is using Mergdata for field surveys and project data management.

UAV (Drones)

Drones are being used to collect remote sensing data from research plots in Ghana (pineapples, mangos); Tunisia (olives). The images are being used to build AI based models to remotely assess crop health and production. Field data/ ground truthing data is required to build, train and test the models. RGB (red-green-blue), NIR (near-infrared), IR (infrared), multi- (MS) or hyperspectral (HS) cameras as well as Lidar scanners

Satellite Imagery

The project is combining UAV images with satellite images to build AI based models to remotely assess crop health and production. The project is using Sentinel-2 mission level 2A. Sentinel-2 satellite imagery is free, covers all project areas, avoids the restrictions on UAV use in some countries and provides data from project sites like Satiri in Burkina Faso which are inaccessible as a result of increasing insecurity, however the technology is not directly usable by farmers and will always require processing by specialists before it can benefit farmers.

InsectaMon

InsectaMon will be an AI based algorithm to identify pest and beneficial insects. The research requires collecting images for all the insects found in the target crops to build a library of images that can be used to build, train and test the AI algorithms. Insects are collected using yellow sticky traps with and without pheromones. The field research teams photograph the sticky traps with their phones and, with the help of project entomologists, identify the insects in the traps. The labelled images are used to build, train and test the InsectaMon algorithm.

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Plant Village Nuru

This a platform of crop protection apps, extension advice and remote farm monitoring tools run by Penn State University in the USA. The free app is available of Google Play and currently provides a suite of AI-based smartphone tools for detecting crop pests and diseases. The tools use AI image recognition algorithms to identify plant diseases. The app can be used to manage a farm, source advice, and track rainfall and plant growth. The web platform can be accessed by administrators to track farms. PlantVillage Nuru - Apps on Google Play

The app is currently free to download and use, available in a range of languages and the AI tools are intuitive. If a farmer can afford a smartphone the app is effective. The app provides public goods, however it must be noted that long term viability of the app is not clear.

Research tools

The Project is using a range of research tools to collect the data required to assess the performance of the technologies against the metrics and for ground truthing to develop remote sensing algorithms. The project does not intend that these tools will be used directly by farmers and so they are not included in the technology scoring.

- The project is using the Soil Plant Analysis Development (SPAD) 502+ chlorophyll meter (Spectrum Technologies, Inc.). The meter is calibrated using crop samples analysed for leaf nitrogen using the Kjeldahl method to link relative Spad values to absolute leaf nitrogen content values. Leaf chlorophyll content is strongly related to the ability of the plant to harvest ambient light and can thus be used as a parameter for estimating the overall performance of a plant.
- Canopy meter. SustInAfrica is using the LI-COR—LAI-2200C Plant Canopy Analyzer to measure Leaf Area Index (LAI), a measure of how much of the field/ plot is covered by the plant canopy.

Work Package 3 Agronomic Technologies and Practices[1]

Burkina Faso

The research is testing the use of biochar made from cotton crop residues and crop rotations to manage soil fertility.

Metrics for assessing the impact of the technology:

- Soil quality parameters (Soil pH, soil carbon, water holding capacity)
- Crop (cotton, maize, legumes) productivity (yield)
- Gross margins (profitability)
- Labour demand disaggregated by gender.

Egypt

Olives

Egypt's olive industry is relatively young and not as well developed as other Mediterranean countries. Heliopolis University is working to develop the Egyptian olive industry, focusing on irrigated organic

[1] As described in Deliverable D3.2 Demonstration Trials, Kwame Frimpong, University of Cape Coast

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olive production. The research is testing organic olive production techniques, comparing the effects of conventional and organic farming systems on soil properties, olive quality and yield and biodiversity.

Heliopolis University is involved in the development and testing of organic crop nutrition and protection products, some of which are used in the trials:

- Biofert is mixture of *Azotobacter chroococcum*, *Bacillus megaterium*, *Baciilus circulance*)
- Bio Power: composed of spores of *Beauveria bassiana* fungus
- biosimulants

Metrics for assessing the impact of the technology:

- Soil quality parameters (Soil pH, soil carbon, water holding capacity)
- Olive yields
- Olive quality (oil content)
- Gross Margins (profitability)
- Labour demand disaggregated by gender.

Dates

Egypt has produced high quality dates, *Phoenix dactylifera,* for 1,000s of years. The project is testing a range of date management practices that have the potential to improve on millennia-old traditional cultivation, crop protection, harvesting and handling practices in the desert oasis in Wahat, El-Ssaf, and El-Ayyat. Practices include: composting; pruning, curving and bending the date's shoots; pollen collection and artificial pollination; covering the dates on the palm using perforated cloth bags; managing fruit set and fruit sizing and inflorescences shedding for the regular distribution of fruits on the palm; separation of palm offshoots. Biological pest control (Red Palm Weevil *Rhynchophorus ferrugineus, etc)*

Metrics for assessing the impact of the technology:

- Soil quality parameters (Soil pH, soil carbon, water holding capacity)
- Date yields
- Gross Margins (profitability)
- Labour demand disaggregated by gender.

Cotton

Egypt has a 140-year history of high quality, high value long staple cotton *(Gossypium barbadense*) production from the Nile Valley and Delta[2]. Long staple cotton is difficult to harvest mechanically and is often harvested and graded manually. Conventional organic production requires high levels of insecticide use to control insects that damage or stain the cotton bolls which degrades the quality and value of the harvested cotton. Heliopolis University has a long-term research interest in promoting the development of an economically viable organic cotton export industry in Egypt to reduce the use of insecticides in cotton. Adoption of organic cotton production in Egypt has been limited and highly variable, as farmers struggle with fluctuations in market demand and international prices. The research is developing organic production methods that will increase cotton yields and quality while decreasing production costs.

Metrics for assessing the impact of the technology:

Above-ground biomass of the cotton plants and the progress of growth will be measured using the following indicators:

[2] Lower quality short staple cottons come from *Gossypium hirsutum*

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- Node number of first fruiting,
- Vegetative branch /plant,
- Primary fruiting branch / plant,
- Secondary fruiting branch / plant,
- Number of bolls / plant,
- Individual boll weight,
- Seed cotton yield
- Fibre yield
- Soil chemical and biological properties
    - Soil content of NPK
    - Soil Water holding Capacity
    - Total microbial count

Ghana

Field trials in Ghana cover test sites of pineapple and maize in the vicinity of Cape Coast, mango orchards in the vicinity of Tamale and a maize trial in Ejura.

Pineapple (Cape Coast)

The productivity and profitability of pineapple production are declining in Ghana. The most important climatic factors for pineapple production in Ghana are rainfall and temperature (Ministry of Food and Agriculture [MoFA], 2013). Long-term rising temperature and rainfall changes towards a longer dry season, as a result of climate change, are major constraints to productivity. Although the crop is highly tolerant to drought, the effects of drought on plant morphology and growth are substantial (Malézieux et al., 2009). Pineapple yields are also declining as a result of declining soil fertility.

In Ghana pineapples are affected by pineapple mealybug, *Dysmicoccus brevipes,* which is a vector of several viruses in the ampelovirus group that are associated with pineapple mealybug wilt disease. Pineapples are also affected by soil-borne pests and diseases: root-knot nematodes, *phytophthora* and fungi (*fusariosis*) resulting in poor yield and fruit quality.

To improve the environmental and economic impact of pineapple production in Ghana the project is testing agroecology-based approaches to address the issues of soil fertility and pest control.

Metrics for assessing the impact of the technology:

- Soil quality parameters (Soil pH, soil carbon, water holding capacity)
- Pineapple yields
- Pineapple quality
- Gross Margins (profitability)
- Insect populations
- Labour demand disaggregated by gender.

Mango

Agronomic activities for mango production such as tillage, manure and fertilizer application, intercropping, pruning, slash-and-burn, use of growth regulators, and pest and disease control have had significant impact on the mango agro-ecosystem, and have also impacted on faunal and floral diversity (Badii et al., 2015). The project is testing mango management practices that will, in theory, reduce the environmental impact of mango production.

Metrics for assessing the impact of the technology:

- Soil quality parameters (Soil pH, soil carbon, water holding capacity)

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- Mango yields
- Mango quality
- Gross Margins (profitability)
- Insect populations
- Labour demand disaggregated by gender.

Maize

Smallholder farmers in SSA often grow cereal crops such as maize (Zea mays L.) in continuous monoculture for food security even when there is limited profitability (Baudron et al., 2012). Intercropping maize with cowpea is one of the most popular mixed cropping combinations under small-holder rain-fed agriculture in the tropics (Abdulraheem & Emmanuel, 2014). It is important to note that cowpea and maize have different growing requirements and require distinct cultivation practices. The underground cowpea residue must remain in the soil to achieve the full nitrogen and organic matter benefits of a cowpea-maize rotation (Uzoh et al., 2019).

Niger

In Dantchandou, Kalfou and Jiratawa, Niger, field trials are testing millet-cowpea intercrop systems. Bluleaf is being tested to assess how much water use can be reduced using the technology, smartphone imagery is being collected to develop the InsectaMon AI model and satellite imagery is being used to develop remote sensing crop health algorithm.

Millet

The millet trials cover:

- Increase soil carbon content: Millet + Farmer Managed Natural Regeneration + Micro-dose with mineral fertilizer/ organic manure/ Animal manure
- Reduce soil erosion: Millet + cowpea intercropped in alternate bands + Living hedges + FMNR
- Biological pest control: Millet + Increase diversity of habitats within or surrounding the fields to support higher insect diversity
- Trials of new crop varieties: Four improved millet varieties (HKP, ECLITAVI, SOSSAT, CHAKTI) and one new Cowpea variety.

Metrics for assessing the impact of the technology:

- Soil quality parameters (Soil pH, soil carbon, water holding capacity)
- Soil erosion/ loss
- Mango yields
- Mango quality
- Gross Margins (profitability)
- Insect populations
- Labour demand disaggregated by gender.
- FMNR: # of stumps, woody growth
- Beneficial organism populations
- Pest populations.

Tunisia

Olives are the most important cash crop in the target regions. More than 97% of the olive area is rainfed. The soils of Tunisian olive orchards have low water holding capacity and low soil fertility, and experience long periods of soil water deficit that coincided with the active fruit growth and oil

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synthesis. Most Tunisian soils have low organic matter content (less than 1%), and are slightly alkaline/basic (>7.8pH) due to the underlying limestone. The cation exchange capacity is low and the nutrients circulation and roots assimilation is limited (Gargouri et Mhiri 2003 ; Boussadia 2004). Three agro-ecological zones (AEZs) were identified for Olive field trials: Beja, Monastir and Sousse. From these AEZs.

The project is testing no till in olive orchards, with wild plants acting as a cover crop, compost, cover cropping with Faba bean and fenugreek. The trials are using sticky traps for collecting images of the Olive Fruit fly *Bactrocerca oleae* and Olive Moth/ Olive Kernel Borer, *Prays oleae.*

Metrics for assessing the impact of the technology:

- Soil quality parameters (Soil pH, soil carbon, water holding capacity)
- Soil erosion/ loss
- Mango yields
- Mango quality
- Gross Margins (profitability)
- Insect populations
- labour demand disaggregated by gender.
- FMNR: # of stumps, woody growth
- beneficial organism populations
- pest populations

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Summary of Technology Scores (August 2023)

Technology	SDGs	Gender	Nutrition	Climate	Environment	IP	Exploitation Strategies
WP2 technologies							
BluLeaf	2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Commercial product
Insectamon	2	Awaiting data	Awaiting data	Passed	Awaiting data	Not completed	Pending
Drones/ UAV	2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. Major IP issues of concern	Commercial product
Satellite Imagery	2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Pending
Plant Village Nuru	2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public goods
Burkina Faso							
Biochar in a cotton maize crop rotation system	2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Biochar in a triennial cotton-maize-cowpea rotations	2,	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Biochar in sorghum-cowpea intercropping	2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Egypt							
Olives: Conventional fertilization and pest control + intercropping	1, 2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Olives: Conventional pest control + biofertilizers	1, 2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Olives: Olives: Conventional pest control v Bio Power (spores of *Beauveria bassiana* fungus	1, 2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Dates: organic production & GAP (pest control,	1	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods

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Technology	SDGs	Gender	Nutrition	Climate	Environment	IP	Exploitation Strategies
fertilization, crop management)							
Behira. Cotton: Conventional fertilization v biofertilizers[3]	1	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Behira. Cotton: Conventional pest control v biological pest control (Trichograma)	1	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Ghana							
Pineapples: plastic mulch + biochar + compost	1	Awaiting data	Awaiting date	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Maize (Vitamin A biofortified maize) - soybean intercropping	2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Maize (Vitamin A biofortified maize) – soybean – compost	2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Maize (Vitamin A biofortified) -soybean-biochar		Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Maize-Soybean-compost		Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Tamale: Mangos: intercropping with Pigeon pea, Mucuna, Common beans	1,2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Mango: Bluleaf, not started		Awaiting data	Awaiting data		Awaiting data		Commercial product
Niger							

[3] (nitrogen fixing bacteria, phosphate-solubilizer and silicate-solubilizer bacteria),

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Technology	SDGs	Gender	Nutrition	Climate	Environment	IP	Exploitation Strategies
Increase soil carbon content: Millet + Farmer Managed Natural Regeneration (FMNR) + Micro-dose with mineral fertilizer/ organic manure/ Animal manure	1,2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Reduce soil erosion: Millet + cowpea intercropped in alternate bands + Living hedges + FMNR	1,2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Biological pest control: Millet + Increase diversity of habitats within or surrounding the fields to support higher insect diversity	1,2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Millet trials: HKP, ECLITAVI, SOSSAT, CHAKTI	1,2	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Cowpea trials	1,2	Awaiting data	awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Tunisia							
Olives: no till	1	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Olives: with Faba bean as the cover crop	1	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Olives: with fenugreek as the cover crop	1	Awaiting data	awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods
Olives: compost/ manure 2 tonnes per ha.	1	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Public Goods

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Technology	SDGs	Gender	Nutrition	Climate	Environment	IP	Exploitation Strategies
Olives: irrigation management with BluLeaf + treatments	1	Awaiting data	Awaiting data	Passed	Awaiting data	Completed. no significant IP concerns	Commercial product

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Scoring Scales

SDGs

1: No Poverty
2: Zero Hunger
3: Good Health and Wellbeing
5: Gender Equality
6: Clean Water and Sanitation
8: Decent Work and Economic Growth
9: Industry, Innovation and Infrastructure
10: Reduced Inequalities
11: Sustainable Cities and Communities
12: Responsible Consumption and Production
13: Climate Action
15: Life on Land

Socio Economic Screening Status: Gender

Socio Economic Screening Status: Nutrition

Socio Economic Screening Status: Environment

Replicability Screening Status

Scaling Readiness data Screening Status

1. Awaiting data
2. Under review
3. Passed
4. Passed with concerns
5. Rejected due insufficient/ Inconclusive data

Proof of concept status

- Passed, no additional PoC testing required
- Passed subject to PoC testing
- Pending

IP screening

1. Not completed
2. Completed. No significant IP concerns
3. Completed. Some IP issues of concern
4. Completed. Major IP issues of concern

Stakeholder screening status

- Completed
- Almost completed. Awaiting feedback from some minor stakeholders
- In progress

Institutional barriers to adoption screening

- Completed. No significant barriers
- Completed. Some barriers noted
- Completed. Major barriers to adoption
- In progress

Exploitation route: Public Goods/ Commercial Product

- Public goods
- Commercial Product
- Pending

Exploitation Strategies: Public Sector Extension Strategy status

Exploitation Strategies: Business Plan status

- N/A
- In development
- Completed

Policy brief status

- Not required
- In development
- Completed
- TBC

Investor briefs

- Not required
- In development
- Completed

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Discussion

Burkina Faso

Biochar in a cotton maize crop rotation system

Nutrition: This technology is not expected to directly impact positively or negatively on current nutrition levels. An increase in maize yields should contribute to household food security, but not to nutrition security, while increases in household income from increased cotton production will only impact on nutritional behaviours if linked to wider nutrition behaviour change interventions beyond the scope of this project. Secondary data indicates stunting and wasting rates in children <5 years is at 19.6% (below regional average) and 7.7% (slightly above regional average) respectively (2020) (Global Nutrition Report 2022) and anaemia in women of reproductive age is at 52% (high and not reducing). A Nutrition report based on secondary data is in development.

Gender: This technology is not expected to directly impact positively or negatively on current gender roles. The baseline gender data is not clear on women's access to and control of crop production. An increase in maize yields should contribute to household food security, but this will require women's control over the utilisation of the harvest. There is no indication that women have control over cotton production and sale. It is not clear how much women rely on cotton crop residues for firewood, if biochar production will reduce the fuel sources and if this will increase the time women spend looking for firewood. It is assumed that men will make the biochar but women may be expected to apply it during field preparation.

Climate: Biochar should in theory improve soil water retention, ensuring that cotton and maize avoid water stress. This is a clear advantage for both crops. For cotton this would extend the growing season, ensuring that the bolls open during the dry season, avoiding the risk of boll staining from rain. It is not clear if the quantities of biochar that can be made locally would be sufficient to hold the amount of water required. More data is required. The production and utilisation of biochar also has potential to reduce the emissions created by burning agricultural waste, though the carbon sequestration will likely be difficult to measure in this context.

Environment: In many cotton growing areas farmers are required to burn cotton crop residues to prevent the carry-over of insect pests, so making biochar from cotton crop residues instead of open field burning will reduce the net amount of carbon released into the atmosphere and, by using the biochar to enhance soil fertility, sequester carbon in the soil. This technology therefor has potential environmental benefits, however there is risk that if insufficient biochar is produced from cotton residues, demand may encourage farmers to cut natural vegetation for biochar production.

Biochar in a triennial cotton-maize-cowpea rotations

Nutrition: This technology could impact positively on current nutrition levels. Cowpeas (*Vigna unguiculata*, Niebe) are a multipurpose food crop. The pods can be eaten green, the leaves are cooked as a green leafy vegetable in Africa, the dried beans are one of the most important sources of plant protein in the Sahel and the roots are cooked in some African cultures.

Gender: This technology could impact positively on women as cowpeas are frequently under the control of women in traditional households, however the baseline data is not sufficient to determine women's access and control over individual crops.

Climate: The impact is likely to be mixed. There are major concerns over the long-term viability of maize in the Sahel regions as temperatures rise however cowpeas are well adapted to low rainfall and are the main legume crop in the Sahel.

Environment: No net impact on the environment is expected. The cowpeas will fix some nitrogen, but this will be utilised by the cotton and maize. Cowpea trash could increase soil organic matter levels but is likely to be utilised as animal fodder.

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Biochar in sorghum-cowpea rotations

Nutrition: This technology could impact positively on current nutrition levels. Cowpeas (*Vigna unguiculata*, Niebe) are a multipurpose food crop. The pods can be eaten green, the leaves are cooked as a green leafy vegetable in Africa, the dried beans are one of the most important sources of plant protein in the Sahel and even the roots are used in some Africa cultures. Ideally a nutrition education component would add value to the potential of nutrition improvement which is not part of this research programme.

Gender: This technology could impact positively on women as cowpeas are frequently under the control of women in traditional households, however the baseline data is not sufficient to determine women's access and control over individual crops.

Climate: Positive impact is anticipated. Cowpeas and sorghum are well adapted to low rainfall and are the main legume crop in the Sahel.

Environment: No net impact on the environment expected. The cowpeas will fix some nitrogen, but this will be utilised by the sorghum. Cowpea trash could increase soil organic matter levels but is likely to be utilised as animal fodder.

Egypt

Olives: Conventional fertilization and pest control + intercropping

Nutrition: Olives are highly nutritious and a rich source of Vitamin A, Vitamin E, and Vitamin C (antioxidants). Olives in small quantities daily are a healthy food option and are part of the "healthy" Mediterranean diet. Farmers mainly grow olives as a cash crop for economic returns with a portion possibly used in the household. Depending on which crops olives are intercropped with will either positively impact on nutrition or not. In Egypt acute and chronic malnutrition in children under five are not a major issue at 9.5% and 22.3% however overweight and obesity in children 5-19 years is a significant issue at 37.2% and 35.8% girls and boys respectively. However, overweight and obesity in adults is at alarming levels with overweight in women at 69.5% (obesity at 41%) and in men 57.2% (obesity 22.7%) 2016 - Global Nutrition Report. This is a major public health issue.

Gender: Socially prescribed gender roles and lack of land ownership decreases women's control over the olive crop specifically, however women often can have more control over crops intercropped with olives. Awaiting further data with regard to women's access and control over intercropping. Women's access to mobile phones is far less than men in Egypt.

Climate: Intercropping has the potential to protect soil health while also reducing irrigation requirements by increasing water storage in the root zone, reducing inter-row evaporation, and controlling excessive transpiration.

Environment: Non-chemical efforts to manage insects and grow soil health support biodiversity of beneficial insects and microbiomes for targeted crops which turn support the health of the wider agroecological system.

Olives: Conventional pest control + biofertilizers

Nutrition: Although olives are nutritionally important and high in Vitamins A, C and E they should only be eaten in small quantities on a daily basis. Without nutrition education/promotion the nutrition impact will be limited if any.

Gender: As above.

Climate: As above

Environment: As above

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Olives: Conventional pest control v biofertilizers

Nutrition: In terms of Olives - as above for nutritional value of the olive itself. Intercropping, depending on the crop, if a nutritious crop and an element of nutrition education/promotion included could have a positive impact on nutrition outcomes. However, this research pilot programme without some nutrition education will likely not have any impact on nutrition outcomes.

Gender: Gains including increased profits that may be experienced because of improved efficiency in production, increased pest control, use of biofertilizers and intercropping may not improve household well- being if women have little or no agency with regard to decisions being made about how income from olives is utilized within the home. Awaiting further data on this.

Climate: As above.

Environment: As above.

Dates: Organic Production & GAP

Nutrition: Dates are a significant nutritious food high in micronutrients especially some minerals such as copper, magnesium, manganese and potassium. It is also a good source of antioxidants which reduces risk of free radicals in the body. Mainly made up of carbohydrates but also high in fibre therefore good for gut health. A useful snack food. Together with intercropping dependent on the crops it may be a beneficial nutritious source especially if a nutrition education/promotion component is included. Unfortunately, there is no nutrition education/promotion component in the research programme.

Gender: The date palm tree has great socioeconomic importance and nutritional value in Egypt. Dates do not rot when ripe and so can be stored for long periods which is seen by many women as a great benefit as well as being able to use other parts of the tree to generate income for example the leaves are used to weave rugs and make baskets and screens and the seeds are used to make prayer beads and sometimes ground for small animal feeds. Intercropping can have distinct advantages for women as men make most decisions around fertilization and pest control while women can often have more control over what's intercropped – we are awaiting more data with regard to intercropping.

Climate: Dates are a desert crop, highly adapted to high temperatures, and are unlikely to effected by the predicted changes in the climate of the western desert.

Environment: Unlikely to have any negative impact on the environment.

Cotton: Conventional fertilization v biofertilizers

Nutrition: Cotton as the main crop will not have a direct impact on nutrition outcomes

Gender: Men control the cotton market in Egypt with women having no real voice with regard to its production and sale within the family farm. The land is owned by the men and at a recent workshop with cotton farmers they explained that as head of the household they make decisions with regard to all aspects of production including fertilization and pest control etc. However, intercropping could prove to be beneficial for women as in most cases women have more control over these crops (such as in the case of cowpeas for example) - we're awaiting more data to verify if this is the case. Most women also lack access to mobile phones making it very difficult for them to benefit from digital technology.

Climate: As long as irrigation water resources remain sufficient for cotton production climate changes will not impact on cotton production.

Environment: Reducing the use of conventional fertilisers through the use of microbial biofertilizers has the potential to reduce the amount of nutrients reaching the Mediterranean Sea, reducing the risks of eutrophication, however this needs to be tested. The high levels of water extraction from the Nile for irrigation reduce the amount of water, and hence nutrients, reaching the sea. Reduced nutrient runoff from upstream user

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may require downstream users to apply more fertilisers in locations with a greater probability of the nutrient runoff reaching the sea.

Cotton: Conventional pest control v biological pest control with *Trichogramma* sp.

Nutrition: Cotton is mainly a cash crop and probably male dominated. It is unlikely that resources from the sale of the cotton will be specifically targeted at purchasing more nutritious food for the household. This is specifically the case if there is no education on nutrition in general, the importance of good nutrition for health and identifying foods valuable for good nutrition. Given the current nutrition statistics for Egypt with overweight/obesity in children 5-19 years and adults at an extremely worrying situation it is unlikely the current focus will have a positive impact on nutrition.

Gender: As above

Climate: As above.

Environment: Conventional cotton production requires high levels of insecticide applications to prevent damage by insects to the cotton bolls. Trichogramma is a parasitoid wasp widely used in horticulture to control cotton bollworm (*Helicoverpa armigera*) and other lepidopteran pests. If the research is effective, it will reduce the need to use insecticides in both target farmers cotton fields and possibly in neighbouring fields.

Ghana

Pineapples: plastic mulch

Nutrition: Nutrition with levels of wasting and stunting in children < 5 years is at 6.8% and 17.5% (stunting levels on target and significantly lower than the regional average). Overweight/obesity in adults is high at 41% for women and 22.1% for men (2016) Global Nutrition Report - country profiles. No negative or positive impacts expected. Though pineapples and other fruits are very important in a diverse diet, households producing pineapples are likely to already be consuming pineapples rejected for sale and increases in production levels are unlikely to significantly change household consumption. Household pineapple consumption is also constrained by the high acidy, which can damage teeth if over consumed.

Gender: Women's main role in generating income from pineapples is to add value to the pineapples which men own and control in the main. Use of plastic mulch should lead to increased production and thus ensure availability for household consumption as well as for sale with women benefiting from adding value to the pineapples and thus increasing HH income which she has more control over.

Plastic mulch reduces, or completely suppresses, weeds. In Africa weeding is often carried out by women so plastic mulch should reduce women's labour, however the soil has to be carefully cleaned before laying the plastic, removing all tree roots and stones that may damage the mulch, which could increase the time women spend in field preparation.

The baseline data on women's roles in pineapple production and data on labour requirements from the trials is not yet available so these assumptions have not been tested.

Climate: High potential impact. The use of plastic mulch is a recognised approach to reduce water stress in crops by reducing evaporation from the soil surface and competition for soil water by weeds.

Environment: despite the excellent growth of pineapples grown under plastic mulch there are concerns over the use of plastic mulch. Biodegradable plastic mulch is too expensive for pineapple farmers and there are no recycling facilities for standard plastic mulch. Standard plastic mulch is liable to break down under UV and add to the microplastics in the soil.

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Pineapple: biochar

Nutrition: No negative or positive impacts expected. Though pineapples and other fruits are very important in a diverse diet, households producing pineapples are likely to already be consuming pineapples rejected for sale and increases in production levels are unlikely to significantly change household consumption.

Gender: Women's workload may be increased if they have to apply the biochar during field preparation assuming men make the biochar. Biochar production may compete with firewood collection, forcing women to travel further to collect firewood and may lead to unsustainable wood harvesting.

Climate: In theory the use of biochar will reduce climate related water stress in pineapples if enough biochar is used, but if the quantities of biomass (maize cobs) required to produce biochar exceed the production capacity from agricultural waste, producers may be incentivised to cut other vegetation for biochar production which defeat its climatic benefits.

Environment: positive impact expected. Biochar should increase soil fertility and soil water holding capacity, while sequestering carbon in the soil, but this will depend on the quantities of biochar that can be produced and the source of the biochar.

(Pineapple: cover cropping (Mucuna))

This research has been postponed.

Nutrition: No negative or positive impacts expected. Mucuna, *Mucuna pruriens,* seeds are only edible by humans after long cooking and treatment and can cause allergic reactions. Mucuna is a high protein fodder crop, so may indirectly increase availability of animal source foods.

Gender: As above. Mucuna produces a dense cover crop which may overwhelm the crop or increase the effort required during harvest, but this may be balanced by the reduced need for weeding. Data from the trials on labour requirements will clarify this question. Wild varieties are notorious for producing severe itching and even blindness, when touched. Commercial varieties of mucuna have fewer irritating hairs.

Climate: Cover cropping with Mucuna should help retain soil moisture both directly and through increasing the water holding capacity of the soil, protecting the crop from increasing temperatures, however this needs to be tested to ensure that the Mucuna is not competing with crop for moisture.

Environment: Strong positive benefits expected. Mucuna is nitrogen fixing and, under the right environmental conditions, produces large quantities of biomass that can rapidly increase soil organic matter (SOM) levels. Mucuna is widely used to restore the fertility of heavily degraded soils and can be used to control invasive Spear Grass, *Imperata cylindrica*. Mucuna can become invasive, but this has not been reported as an issue in Africa.

Pineapple: compost

Nutrition: No negative or positive impacts expected.

Gender: Women play a key role in providing compost using HH waste etc especially if they have received training with regard to the production of compost and the role it plays in pineapple production - however often women are overlooked or forgotten when training is being provided by extension services because of entrenched attitudes and social norms.

Climate: Positive benefits expected from increasing the water holding capacity of the soil, but the benefits will depend on the quantities of compost available. If quantities are limited microdosing will have to be used that, while an efficient way to maximise nutrient use, will not significantly change soil water holding capacity.

Environment: Positive benefits expected as compost will increase soil fertility, soil organic matter, may raise soil pH in acidic soils and increase soil biological activity. The level of impact will depend on soil type and the quality and quantity of compost that can be produced and transported to the fields. Over several season compost applications can be expected to raise moderately acidic soils from 5.6 to 6. In very acidic soils farmers struggle to produce and transport the quantities of compost required to increase soil pH to acceptable levels.

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Maize – soybean intercropping with/ without compost or biochar

Nutrition: This technology could impact positively on current nutrition levels, particularly for children. The maize variety is reported to be a new vitamin A biofortified orange maize variety and soybean (*Glycine max*) is a high protein crop that can be processed at the household level and used either as a pulse or the flour can be used to fortify maize, wheat, cassava and other flours. It is not clear how much soybean is used for home consumption or if the crop is sold for oil and animals feeds. It is assumed that the orange maize will be used for direct household consumption and not sold as a cash crop. Ideally a nutrition education component would add value to the potential of nutrition improvement which is not part of this research programme.

Gender: Men are more likely to have control over the income from maize than women with women having less agency in terms of their ability to make decisions and define goals in relation to all aspects of growing maize, though the gender dynamics may be different for orange maize. In some cultures, hybrid yellow or white maize is controlled by men but orange maize may be treated as a "vegetable" and a women's crop. More information is needed on the status of soybean. If it is grown as a cash crop it is likely to be controlled by men, but if grown for household nutrition then women may have control over the crop.

Climate: Intercropping with soybean has the potential to protect soil health while also reducing irrigation requirements by increasing water storage in the root zone, reducing inter-row evaporation, and controlling excessive transpiration. Compost and biochar can also increase water holding capacity if sufficient quantities are applied. Not enough is known about the maize variety being grown to determine its response to rising temperatures, which could exceed the optimum thresholds for maize production.

Environment: Intercropping with soybean will reduce or avoid the need for nitrogenous fertilisers in the maize crop. The level of nitrogen fixation by the soybean may be limited by the levels of phosphates in the soil and the presence of appropriate strains of rhizobium in the soil. If P levels are low or rhizobium is not already present in the soil soybean N fixation will be low and the soybean will compete with the maize for soil N. Unless rhizobium is already present in the soil (if a good yield of soybean has been obtained within the past 3 seasons) or the soybean variety is a promiscuous variety, the trials should include treatment with an appropriate rhizobium inoculant. Compost should increase microbial and invertebrate diversity in the soil. Biochar pre-treated with plant nutrients acts as a slow release fertilisers, reducing the levels of nutrients leached out of the soil.

Mangos: intercropping with groundnut, pigeon pea, Mucuna or common beans

Nutrition: Positive impact expected as mangos (*Mangifera indica*) are a good source of vitamin A and C, pigeon peas (*Cajanus cajans*) and common beans (*Phaseolus vulgaris*) are important protein crops for use at household level. It is unlikely that any increases in mango yield will change the current nutrient status of producing households, as these households are likely to already consume significant quantities of mangoes rejected by the market. Though Mucuna can be processed and eaten at home, this is not common in Africa and the crop is grown primarily for N fixation, soil cover and soil organic matter. Mucuna can be used as fodder, which could indirectly increase access to animal source foods.

Gender: There is a classic gender gap between men and women mango growers in farm level decision making with men holding most of the power, control land ownership and supply inputs and the sale of the crop even though many of the farm activities are undertaken by women. Intercropping with pigeon pea or common beans should benefit women benefit as its customary for them to control these crops and make decisions around how income is used for the wellbeing of the family.

Climate: no net impact expected from intercropping with pigeon peas, common beans or mucuna. Mangoes are deep rooted and extract water from well below the level of the cover crops so there will be no competition for water, and any mulching benefits of the cover crops will not impact on the mangoes.

Environment: In theory intercropping with pigeon peas, common beans or Mucuna will provide N for the surface feeder roots of the mango trees, however the level of N fixation by these crops will probably be limited by

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competition for phosphates by the mango trees. The low light levels in mature mango orchards will severely restrict cover crop growth and is likely to reduce the number of pods per plant.

Niger

Millet

Increase soil carbon content: Pearl Millet + Farmer Managed Natural Regeneration (FMNR) + Micro-dose with mineral fertilizer/ organic manure/ Animal manure

Nutrition: Malnutrition is a major issue in children <5 years with acute and chronic levels at 11.5% and 44.4% respectively (2021). Chronic malnutrition is significantly higher than the African region at 31.5%. There is no progress in anemia levels in women of reproductive age at 49.5%. Overweight and obesity becoming an issue in adults with overweight in women at 29.7% and men at 14.6% (2016) - Global Nutrition Report. Pearl Millet (*Pennisetum glaucum*) is already the staple crop for much of Niger so while increasing the yield of pearl millet through agronomic practices may increase food security it is unlikely to have a large impact on dietary diversity and nutritional security. One of the varieties of pearl millet is a biofortified variety, with increase iron levels. Consumption of biofortified pearl millet has been shown to increase Fe levels in children in India, though the sample size was small.

The use of zinc fertilisers, either as foliar feed or added to standard micro-dosed fertilisers, is proven to increase Zinc levels in the grains in Zn deficient soils, and Zinc fortification of commercial fertilisers is now mandated in several countries as a public health measure to help address Zn deficiencies in the diet of children which is linked to malnutrition and the immune system (health issues).

FMNR can directly add to dietary diversity through the selective regeneration of indigenous fruit and nut trees (*Balanites aegyptiaca, Ziziphus mauritiana, Vitellaria paradoxa /Butyrospermum parkii/ shea tree, Detarium sp., Grewia sp., Andansonia sp., Hyphaene sp., Nymphea, Saba sp., Parkia biglobos*a (karite). etc) and enrichment planting with other fruit and nut species (mangoes, cashew nuts, *Moringa olifera*), and indirectly through the selective regeneration of fodder species for cattle, camels and goats.

Gender: Gender inequality in terms of decision making in farm related decisions are very common in the production of Millet which is seen as a male crop in NIger. Women undertake a large share of the farm activities related to the production of pearl millet but men mainly make decisions around FMNR, dose of mineral fertilizer, organic manure and animal manure.

Though trees are generally owned by the landowner, women usually have the right to collect and process fruit and nuts, and the Shea nut butter value chain is entirely controlled by women in West Africa, as is the production of the condiment *dawadawa* from *Parkia biglobosa*.

Climate: High positive impact. FMNR has been proven in numerous studies to increase resilience to climate change in the Sahel.

Environment: High positive impact expected. FMNR was developed in Niger and Burkina Faso and has proved to be a highly effective, low-cost approach, for restoring degraded landscapes and restoring soil fertility.

Reduce soil erosion: Pearl Millet + cowpea intercropped in alternate bands + Living hedges + FMNR

Nutrition: Pearl Millet (*Pennisetum glaucum*) is already the staple crop for much of Niger so while the increasing the yield of pearl millet through better agronomic practices may increase food security it is unlikely to have any direct impact on dietary diversity and nutritional security unless biofortified varieties are grown. Cowpeas, as noted in previous sections, are an important, possibly the main, source of protein in the diet in rural Niger so increases in cowpea production will increase household nutrition. The carefully selection of fruit and fodder tree

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species for the hedgerows can fill gaps in the nutrition calendar (periods when cultivated crops are unavailable), and planting fodder trees as hedgerows could indirectly increase assess to animal source foods.

Gender: As is the case for the majority of women in Africa, intercropping usually benefits them as they have access to the particular intercropped crop/s and can make decisions around its sale and how income is used within the HH thus increasing their sense of agency and self-confidence.

Climate: High positive impact. Living hedges, like FMNR, is a proven technology to increase resilience to climate change in the Sahel, however living hedges have proved to be harder to promote than FMNR due to the work required to maintain the hedges and the perceived loss of productive land. The hedges reduce both wind and soil erosion and depending on the spacing and orientation, may reduce crop canopy and soil surface temperatures. Reducing windspeed and canopy temperature should reduce crop evapotranspiration and the risk of water stress.

Environment: High positive impact. The hedges reduce both wind and soil erosion and by reducing windspeed, reduce crop evapotranspiration. Leave fall from the hedge provides a source of crop nutrients from deeper soil levels that crops cannot normally access. Branches pruned from the hedge could be used as a mulch to improve soil fertility and biological activity, but in Niger these are more likely to be used for firewood. The use of hedge prunings for firewood may indirectly reduce the need to source firewood from natural vegetation.

Biological pest control: Pearl Millet + Increase diversity of habitats within or surrounding the fields to support higher insect diversity.

Nutrition: as above.

Gender: As above.

Climate: Difficult to determine at this stage as it will depend on the species mix and growth of the vegetation tested for increasing insect diversity. The natural vegetation may help ameliorate the climate conditions within the field or may compete with the crop for soil water.

Environment: In theory the natural vegetation provides a habitat for predatory and pollenating invertebrates, reducing the need for insecticide use in crops. Though this technology will increase on-farm biodiversity it is impossible to determine at this stage how effective the technology will be as it will depend on the species mix of the natural vegetation. There is a risk that the natural vegetation will be dominated by a single species, potentially an invasive species, or that some of the natural vegetation species will provide alternative hosts for insect crop pests or provide refuges for pest species to survive (carry-over) between cropping seasons.

Pearl Millet trials: HKP, ECLITAVI, SOSSAT, CHAKTI

Nutrition: Pearl Millet (*Pennisetum glaucum*) is already the staple crop for much of Niger so while the adoption of new, higher yielding, pearl millet varieties may increase food security it is unlikely to have any direct impact on dietary diversity and nutritional security.

New Iron and Zinc rich pearl millet varieties are now available, with 2 OPVs and 9 hybrids of Iron and Zinc rich pearl millet released by Harvest Plus in India and Niger. There is evidence from Randomised Control Trials (RCT) in India that consumption of these varieties increased the Fe and Zn levels in 2year old children, however None of the varieties selected for these trials are Fe and Zn.

Gender: Pearl millet is a staple crop in Niger and therefor largely managed by men, with women expected to process the crop.

Climate: Pearl millet is well adapted to the Sahel semi-arid climate. The trials will test if the newer varieties have the same or better levels of adaptation to drought than existing varieties.

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Environment: No net difference is expected as the new varieties would simply replace existing varieties, with no increase in farm size that could require clearing new land.

Cowpea trials

Nutrition: As cowpeas are the main source of protein for the poorest households in Niger, increases in cowpea production through the use of higher yielding varieties should positively impact on household protein intake. Fe biofortified bean varieties are now widely available across Africa but there have been limited studies on the potential to breed Fe and Zn rich varieties of cowpea.

Gender: In Africa traditional cowpea seeds are generally stored and managed by women, giving women control over decisions around cowpea use and sale. However more field data is required to determine if this assumption applies to the communities in Niger. As new varieties will have to be purchased from agro-input dealers this may change the gender dynamics, with men controlling the purchase and use of the new varieties. This hypothesis also needs to be tested with field data. There is a risk that women in Niger may be excluded from training/learning sessions due to social and cultural norms and their lack of access to mobile technology.

Climate: Cowpeas are widely grown across the Sahel and cowpeas are well adapted to the Sahel semi-arid climate. The trials will test if the newer varieties have the same or better levels of adaptation to drought than existing varieties.

Environment: Cowpea generally has a positive impact on soil fertility in terms of N fixation, provided that there is sufficient P in the soil. The new varieties will probably be planted as a replacement for existing cowpea varieties so the net benefits will be minimal.

Tunisia

Olive production in the central and south of Tunisia is predominantly from smallholder farms, with larger intensive, high tree density, olive production in the north. Since the start of the project the socio-economic context has changed. Olives no longer provide most of the income for smallholder farmers, who can no longer afford to spend 100% of their time on olive tree management and are increasingly managing their olive orchards remotely. There is therefore increasing interest in technologies for remote management. Irrigation is necessary as fruit production occurs during the driest period of the year and the main winter rains do not provide sufficient soil water recharge to support large harvests. There is no tradition of cover cropping in the central and south.

Olives: no till

Nutrition: Secondary data from the Global Nutrition Report indicate that acute and chronic malnutrition levels in children <5 years are extremely low in Tunisia at 2.1% and 8.5% respectively (falling well below the regional average which is a huge positive). However, overweight and obesity in children 5-19 years is climbing at 24% while in adults it is a major public health issue with overweight in women at 65.8% (obesity 34.5%) and in men slightly lower at 57.1% (obesity 19.2%) 0 Global Nutrition Report - country profiles. The technologies being tested in Tunisia will have no positive or negative impact on the obesity crisis.

Gender: The gendered workload studies conducted by the project show that women in the smallholder olive farms are heavily involved in harvesting the olives. No Till technology will not reduce women's workloads at harvest time. The project has supported the use of mechanical harvesting to reduce workloads.

Climate: Not expected to significantly change resilience to future climates. No Till will reduce water runoff and increase water infiltration into the soil but the deep roots of the olive trees are probably accessing water from deeper soil levels that unlikely to be directly affected by No Till.

Environment: No till farming provides a wide range of environmental benefits and services:

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- Increased water infiltration and retention by the soil, together with reduce evaporation, which reduces water run-off, and ensures more water is available for the crop throughout the growing season.
- Enhancing biological activity above and below ground, including increased populations of mycorrhizal fungi (Glomus, and other genera)
- Reduced soil crusting.
- Reduced soil erosion by wind.
- Improve physical and chemical properties of soils in planting zone, with long term improvements in soil fertility.
- Carbon sequestration: CO2 sequestered per hectare (0.05 – 0.2 metric tons ha-1yr-1) is small, but significant if widely adopted.
- Some research indicates that CA increase rates of denitrification, leading to increases in N_2O and CH_4 emissions – both of which have a greater greenhouse effect than CO_2.

	No Till better	No difference	Conventional Tillage better
Soil moisture infiltration & retention	✓		
Carbon Sequestration	50	50	
N_2O/ CH_4 Emissions	50		50
Soil (wind and water) erosion	✓		
Soil biodiversity	✓		

Table 1: summary of proven environmental benefits of no till

Olives: intercropping with faba bean, *Vicia faba*

Nutrition: Faba bean (*Vicia faba*, broad bean) is the staple pulse across most of the Maghreb. Intercropping with faba bean will increase access to protein however secondary data sources show that Tunisia (and Egypt) suffers from exceptionally high levels of obesity rather than undernutrition and this technology will have no positive or negative impact on the obesity crisis.

Gender: Not enough data is available on the role of women in faba bean production and sale to determine what impact increasing faba bean production will have on women's lives.

Climate: Same as above.

Environment: Same as above.

Olives: with fenugreek *Trigonella foenum-graecum* as the cover crop

Nutrition: Fenugreek is native to northern Tunisia. Fenugreek is a spice crop and, despite its use in traditional and herbal (phytomedicine) medicine, there is limited evidence for beneficial effects on health (Visuvanathan et al., 2022). Fenugreek is also used as a fodder crop (Ahmad et al., 2016), similar to alfalfa, which may indirectly increase the availability of animal source foods in the diet, with unknown effects on obesity levels. Once a high-valued forage, fenugreek is now a minor forage species and fenugreek is grown and harvested principally for the seeds and only secondarily for forage.

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Gender: Women may be expected to apply Fenugreek as the cover crop which adds to their workload.

Climate: Fenugreek appears to be well adapted to the future climate of Tunisia. Fenugreek is fairly drought tolerant, with low water requirements, and will grow on saline soils. It can tolerate high day temperatures as long as the nights remain cool and is suitable for dryland areas where moisture is not sufficient for Berseem, *Trifolium alexandrinum.*

Environment: Fenugreek intercropping is expected to have a range of positive impacts on the environment. Fenugreek is a nitrogen fixing legume fixing but may require rhizobium inoculation and P applications to maximise N fixation. Fenugreek intercropping will increase the biodiversity in olive orchards and it should act as a break crop to prevent the carry-over of winter wheat pests and diseases. As *Trigonella foenum*-graecum is N-fixing it may reduce the need of nitrogen fertilizers for subsequent crop. It has low water requirements and its cultivation might reduce the cost of irrigation, save water, reduce the eutrophication of surface waters, and limit the contamination of ground water sources. Fenugreek seed added to cattle feed in the ratio 60:40 has potential to reduce methane emissions from ruminants and to improve DM digestibility. (Rejil et al., 2007).

Olives: compost/ manure 2 tonnes per ha.

Nutrition: Secondary data sources show that Tunisia (and Egypt) suffers from exceptionally high levels of obesity rather than undernutrition. The technologies being tested in Tunisia will have no positive or negative impact on the obesity crisis.

Gender: Women often contribute to the production of compost but can be excluded from learning how the production of compost can be improved by the extension services etc because of social and cultural norms.

Climate: The use of compost in sufficient qualities will increase the water holding capacity of the soil, reducing the risk of water stress.

Environment: The use of compost in sufficient qualities will reduce the need for synthetic fertilisers and increase soil microbial diversity.

Olives: irrigation management with BluLeaf

Nutrition: Secondary data sources show that Tunisia (and Egypt) suffers from exceptionally high levels of overweight and obesity rather than undernutrition. Olives in themselves are a nutritious crop high in vitamins A, C and E and can have positive health outcomes if eaten as a snack in small quantities. The technologies being tested in Tunisia will have no positive or negative impact on the obesity crisis.

Gender: Women do not have equal access to mobile/digital technology and thus do not benefit in the way men do from learning about irrigation management from BLuLeaf etc.

Climate: BluLeaf has strong potential to maximise water use efficiency.

Environment: In theory better water management will reduce any negative effects of waterlogging (salinity) and reduce the amount of water extracted from surface a groundwater sources.

References

Ahmad, A., Alghamdi, S. S., Mahmood, K., Afzal, M., & Afzal, M. (2016). Fenugreek a multipurpose crop: Potentialities and improvements Production and hosting by Elsevier. *Saudi Journal of Biological Sciences*, *23*, 300–310. https://doi.org/10.1016/j.sjbs.2015.09.015

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Visuvanathan, T., Than, L. T. L., Stanslas, J., Chew, S. Y., & Vellasamy, S. (2022). Revisiting Trigonella foenum-graecum L.: Pharmacology and Therapeutic Potentialities. *Plants (Basel, Switzerland)*, *11*(11). https://doi.org/10.3390/PLANTS11111450

Rejil, M. C.; Mohini, M., 2007. *In vitro* evaluation of feed supplemented with fenugreek seeds (Methi). Indian J. Dairy Sci., 60 (2): 107-113

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