# Opportunity Crop Profiles for the Vision for Adapted Crops and Soils (VACS) in Africa

AgMIP HAVOS.ai The Rockefeller Foundation

African Union AOCC Food and Agriculture Organization of the United Nations

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## Title

Opportunity Crop Profiles for the Vision for Adapted Crops and Soils (VACS) in Africa

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# Preface

**The Vision for Adapted Crops and Soils (or "VACS") is a movement that brings together dedicated communities and individuals from research, advocacy, and policy to shine a light on opportunities that traditional and underutilized crops provide to build more resilient and competitive food systems.**

VACS was launched in February 2023 in partnership with the African Union (AU), the Food and Agriculture Organization of the United Nations (FAO), and the Office of the U.S. Special Envoy for Food Security at the State Department, with an initial focus on the African continent.

This report is an in-depth crop analysis designed to provide a rigorous evidence base to the global community. By conducting a holistic assessment of a variety of well-researched crops (e.g., maize, cassava, soybean and tomato), compared to a non-exhaustive list of neglected and underutilized crops (e.g., opportunity crops, such as bambara groundnut and fonio), we aim to provide actionable insights into the crops that are best equipped to provide stable and nutritious diets in the face of climate variability and extreme weather events in geographies across the continent.

This piece of research is not meant to be exhaustive or exclusionary towards considering a broader set of crops. We hope this process and the findings are a stepping-stone to provide an evidence-based assessment on behalf of a global agenda. This report was produced alongside the *VACS: Research in Action Report*, (also known as the Summary Report) which outlines the guiding concepts of the VACS approach, overviews research conducted to date to expand the evidence base, recommends areas of focus for the movement going forward, and ways to engage in VACS. The Summary Report can be found here.

# Opportunity Crops Assessment Methodology

**Evaluating a critical mass of available evidence and research on a topic –any topic– is a challenge. Here we combine qualitative and quantitative methods to deliver an evidence-based analysis that captures key aspects of the crops we are assessing.**

AgMIP utilizes a tailored suite of climate models within process-based crop simulations to project crop productivity under multiple climate change scenarios. Havos.ai combines human and sophisticated machine-intelligence models to produce a rigorous evidence assessment known as an evidence synthesis. We would like to acknowledge and thank all of the researchers and scholars who contributed their knowledge, expertise and time to VACS research efforts. For a full list of participants involved please see the Annex of the Summary Report here.

Bringing climate-crop modeling and evidence synthesis together facilitates a holistic look at a range of indicators that can be used to assess the unique strengths and weaknesses of each crop.

Specifically, we analyze the crops using a set of indicators that reflect six crop dimensions: biophysical, genetic, nutritional, economic, sociocultural and environmental. These crop-specific attributes are mapped into intervention categories that define pathways by which investments in crop value chains can achieve important social, economic, dietary and environmental outcomes.

Crops are characterized through a series of qualitative and quantitative indicators within each dimension, referred to as Adaptation Indicators (Table 1). These features are determined through various modes of evaluation (Table 2), such as the Star Diagrams (quantitative), Climate-crop Modeling Maps (quantitative) and Intervention Pathways (quantitative and qualitative), which all feed into the Crop Key Features assessment.

### Modes of Evaluation

The adaptive qualities of each opportunity crop are evaluated through three interrelated products: the **star diagram, climate-crop modeling maps, and evidence synthesis**. Each product emphasizes different dimensions of the adaptive profile of a particular crop, and presents information in a slightly different way (Table 2). The crop **key features** legend synthesizes findings from each mode in a simple and easy to understand way.

Table 1 **Adaptation Indicators**

| Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental |
|---|---|---|---|---|---|

| Crop System Dimension | Adaptation Indicators | Intervention Category |
|---|---|---|
| **Biophysical** | High yielding under current climate | On the Farm |
| | Climate-resilient yield potential | |
| | Drought-tolerant | |
| | Heat-tolerant | |
| | Pest-resistant | |
| | Disease-resistant | |
| | Supports animal and livestock health | |
| **Economic** | High value chain potential | Food on the Move |
| | High consumer acceptance | |
| **Sociocultural** | Cultural significance | Empowering the Excluded |
| | Evidence of women's empowerment | |
| **Nutritional** | Relative high concentration of Folate | Nutritious Diets |
| | Relative high concentration of Zinc | |
| | Relative high concentration of Calcium | |
| | Relative high concentration of Protein | |
| | Relative high concentration of Vit. A | |
| | Relative high concentration of Iron | |
| | High lean season value | |
| **Genetic** | High plant genetic resources in Africa | Enabling Environment |
| | High plant genetic resources globally | |
| | Highly developed breeding programs | |
| **Environmental** | Water use efficiency (WUE) | Protecting the Planet |
| | Nutrient use efficiency (NUE) | |
| | Contributes to soil health | |

Table 2 **Modes of Evaluation for Adaptation Indicators**

| Mode of Evaluation | Adaptation Indicator Covered | |
|---|---|---|
| **Star Diagram** | **Biophysical** | Yield under current climate, climate-resilient yield potential, drought-tolerance, heat-tolerance |
| | **Nutritional** | Folate, Zinc, Vitamin A, Calcium, Protein, Iron |
| | **Genetic** | Plant genetic resources in Africa, plant genetic resources globally, scale of breeding programs |
| **Crop Modeling Maps** | **Biophysical** | Climate-resilient yield potential. The crop modeling maps and underlying data inform the quantitative evaluation of climate-resilient yield potential that feeds into the star diagram. |
| **Evidence Synthesis** | The following indicators were assessed by Havos.ai using machine-learning informed evidence synthesis: | |
| | **Biophysical** | Pest-resistance, disease-resistance, supports animal and livestock health |
| | **Nutritional** | Lean season value |
| | **Economic** | Value chain potential, consumer acceptance |
| | **Sociocultural** | Cultural significance, evidence of women's empowerment |
| **Key Features** | **Biophysical** | Pest-resistance, disease-resistance, supports animal and livestock health |
| | **Nutritional** | Lean season value |
| | **Economic** | Value chain potential, consumer acceptance |
| | **Sociocultural** | Cultural significance, evidence of women's empowerment |
| | **Genetic** | Genomic sequencing status |

### Star Diagram Methodology

Each crop is evaluated against the other 26 crops in the Phase 2 study. The list of crops included in the study can be found on page 6. The quantitative scale for each indicator varies based on the available data, and are bespoke to each indicator. The range of the scales are set so that each indicator highlights 3-5 high-performing crops in the study. This helps highlight the relative performance of select crops compared to others in the study. The range between the highest and lowest values is then split into deciles, and each crop is given a number nearest to the integer of the value derived. Qualitative assessments are based on literature and an expert consultation process conducted with plant breeders and plant genetic specialists, such as those representing the African Orphan Crops Consortium.

### Climate Change Assessments with Climate-Crop Modeling

Our evaluation of the biophysical adaptation potential of each crop emphasizes both current yield potential as well projected yield change under climate change scenarios. The climate change assessments are performed using a gridded version of the SIMPLE process-based crop model (Zhao et al, 2019). There are eight climate change scenarios utilized in the assessment, denoted in the table below, combining four Global Circulation Models (GCMs) and two Shared Socioeconomic Pathways (SSPs) (Table 3). The results are communicated through the Crop Modeling Maps.

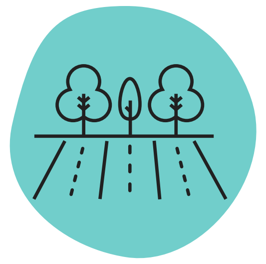
Table 3
**Climate Change Models and Projection Details**

| | |
|---|---|
| **GCMs** | MPI-ESM1-S-HR, MRI-ESM2-0, GFDL-ESM4, IPSL-CM6A-LR |
| **Time Horizon: Baseline** | 1990-2019: 30-year average |
| **Time Horizon: Future period** | 2035-2064: 30-year average ("2050s") |
| **SSPs** | SSP1-2.6: Low emissions scenario, SSP3-7.0: High emissions scenario |

### Evidence Synthesis Overview

Evidence synthesis (commonly known as scoping or systematic reviews) refers to the process of compiling information and knowledge from many sources and disciplines to inform decisions. It uses a carefully worked out methodology that relies on original, high-quality research to evaluate the scope of research in an area or in some cases, determine the impact of interventions and outcomes. The VACS evidence synthesis is a birds-eye view of the breadth of high-quality African-based research about the opportunity crops. This is different from a systematic review which emphasizes causal impact of any single outcome. The review emphasized inclusion of studies focused on 'what works and how' regarding adoption, uptake, and use of these crops by rural communities related to food security and nutrition, economic growth, resilience, environmental sustainability, women's empowerment and inclusivity. There are six intervention pathways that describe the context of the more specific intervention. For example, an On the Farm intervention is Crop Management (intercropping). Depending on the exact nature of the intervention design, a study outcome might be related to economic growth, environmental sustainability, food security & nutrition, or all of the above. Facilitators and implementation barriers are also described.

### The intervention categories are:



**On the Farm**

**Food on the Move**

**Empowering the Excluded**

**Nutritious Diets**

**Enabling Environment**

**Protecting the Planet**

### Interpreting the Intervention Pathways

The opportunity crops profile pages highlight crop-specific intervention pathways. There are five stages per pathway. Each pathway begins with an **Intervention Pathway Category**, such as On the Farm or Food on the Move, to frame the setting in which the intervention is used in the evidence. Next, the **Intervention** is identified, and associated with one or more **Facilitators** as identified from the evidence that led to one or more **Outcome**. The last stage in the pathway is **Current Barriers to Implementation.**

## Table 4 **Key Features Legend**

| Icon | Indicator | Description | Source |
|---|---|---|---|
| | **High yielding under current climate** | Crop yields well under current climate conditions | FAO data, AgMIP process-based climate-crop modeling |
| | **Climate-resilient yield potential** | Crop is projected to maintain stable or increasing yields in high climate change scenarios | AgMIP process-based climate-crop modeling |
| | **Drought-tolerant** | Crop can sustain productivity under drought conditions relative to other crops | Literature review and AgMIP process-based crop modeling |
| | **Heat-tolerant** | Crop can sustain productivity under extreme heat conditions relative to other crops | Literature review and AgMIP process-based crop modeling |
| | **Pest-resistant** | Evidence of solutions for pest resistance | Havos.ai Evidence Synthesis |
| | **Disease-resistant** | Evidence of solutions for crop resistance | Havos.ai Evidence Synthesis |
| | **Supports animal and livestock health** | Evidence of crop delivering benefits for livestock health/feeding | Havos.ai Evidence Synthesis |
| | **High value chain potential** | Evidence of solutions and services to support value chains | Havos.ai Evidence Synthesis |
| | **High consumer acceptance** | Evidence of market consumer acceptance of raw/processed food | Havos.ai Evidence Synthesis |
| | **Cultural significance** | Evidence that the crop is culturally significant through indigenous knowledge transfer | Havos.ai Evidence Synthesis |
| | **Evidence of women's economic empowerment** | Evidence of women's empowerment | Havos.ai Evidence Synthesis |
| * B-9 | **Relative high concentration of folate** | Crop is high in Folate relative to other 26 crops in the study | Data from the FAO Food and Nutrition Division, scaling by AgMIP |
| Zn * | **Relative high concentration of Zinc** | Crop is high in Folate relative to other 26 crops in the study | Data from the FAO Food and Nutrition Division, scaling by AgMIP |
| Ca * | **Relative high concentration of Calcium** | Crop is high in Calcium relative to other 26 crops in the study | Data from the FAO Food and Nutrition Division, scaling by AgMIP |
| * | **Relative high concentration of protein** | Crop is high in Protein relative to other 26 crops in the study | Data from the FAO Food and Nutrition Division, scaling by AgMIP |
| Vit.A * | **Relative high concentration of Vit. A** | Crop is high in Vitamin A relative to other 26 crops in the study | Data from the FAO Food and Nutrition Division, scaling by AgMIP |
| Fe * | **Relative high concentration of Iron** | Crop is high in Iron relative to other 26 crops in the study | Data from the FAO Food and Nutrition Division, scaling by AgMIP |
| * | **High lean season value** | Evidence of crop supporting families and communities' food security during lean season | Havos.ai Evidence Synthesis |
| | **High plant genetic resources in Africa** | Crop supported by significant plant genetic resources in Africa (represented by # of accessions) | Genesys data, Expert consultation (incl. from AOCC experts), compiled by AgMIP |
| | **High plant genetic resources globally** | Crop already supported by significant plant genetic resources globally (represented by # of accessions) | Genesys data, Expert consultation (incl. from AOCC experts), compiled by AgMIP |
| | **Genomic sequencing completed or underway** | Crop genome is already sequenced or sequencing is underway (by AOCC or others) | Literature review and AOCC publications, compiled by AgMIP |
| | **Water use efficiency (WUE)** | Evidence the crop has low water usage in most environments | Havos.ai Evidence Synthesis |
| | **Nutrient use efficiency** | Evidence the crop requires minimal fertilizer to support yield growth | Havos.ai Evidence Synthesis |
| | **Contributes to soil health** | Crop production can benefit soil characteristics | Literature review by AgMIP |

*Food composition data were compiled from African Food Composition Tables (FCTs), namely: FAO/INFOODS Food Composition Table for Western Africa (2019); Kenya Food Composition Tables (2018); and Priority Food Tree and Crop Food Composition Database (2019). Data were compiled for raw foods only including proximate composition (nine components), three minerals (calcium, iron and zinc) and two vitamins (vitamin A and folate).

Table 5 **VACS Indicative, Interim Crop List, from the Phase 1 Workshop**

| Crop Group | Climate-crop models developed by AgMIP, evidence synthesis performed by Havos.ai | Models currently being developed by AgMIP and Havos.ai, with results forthcoming | Prioritized by van Zonneveld et al., 2023 | Common Name | Latin Name |
|---|---|---|---|---|---|
| **Cereals** | ● | | | Teff | *Eragrostis tef* |
| | ● | | | Fonio | *Digitaria exilis* |
| | ● | | | Pearl Millet | *Cenchrus americanus/Pennisetum glaucum* |
| | ● | | ● | Finger Millet | *Eleusine coracana* |
| | | | | Oats | *Avena sativa* |
| | ● | | | Sorghum | *Sorghum bicolor* |
| | | | ● | Barley | *Hordeum vulgare* |
| | | ● | | African Rice | *Oryza glaberrima* |
| **Roots & Tubers** | | | | Enset | *Ensete ventricosum* |
| | ● | | ● | Cocoyam | *Xanthosoma sagittifolium* |
| | ● | | ● | Yams | *Dioscorea* spp. |
| | ● | | | Cassava | *Manihot esculenta* |
| | ● | | ● | Taro | *Colocasia esculenta* |
| | ● | | | Sweet Potato | *Ipomea batatas* |
| **Fruits** | | ● | | African Locust Bean | *Parkia biglobosa* |
| | | | ● | African Sugar/Custard Apple | *Annona squamosa/senegalensis* |
| | | | | Miracle Berry | *Synsepalum dulcificum* |
| | | ● | | Desert Date | *Balanites aegyptiaca* |
| | | | | Wild Loquat | *Uapaca kirkiana* |
| | | | ● | Breadfruit | *Artocarpus altilis* |
| | | | | Jackfruit | *Artocarpus heterophyllus* |
| | | ● | | African Jujube | *Ziziphus jujuba/mauritania* |
| | | | | Cooking Banana | *Musa × paradisiaca* |
| | | ● | ● | Bushmango | *Irvingia gabonensis* |
| | | ● | | Plantain | *Musa balbisiana* |
| | | | | Baobab | *Adansonia digitata* |
| **Vegetables** | | | ● | Black Jack | *Bidens pilosa* |
| | | | ● | Gourd species | *Lagenaria siceraria* |
| | | | | Ethiopian Mustard | *Brassica carinata* |
| | | | ● | Spider Plant | *Cleome gynandra* |
| **Vegetable (cont.)** | | ● | ● | Moringa | *Moringa oleifera* |
| | | ● | | African Leafy Nightshade | *Solanum scabrum/americanum* |
| | | ● | ● | Jute Mallow | *Corchorus olitorius* |
| | ● | | | African Eggplant | *Solanum aethiopicum/macrocarpon* |
| | ● | | ● | Amaranth | *Amaranthus* spp. *(cruentus, caudatus, hybridus, graecizans, viridis)* |
| | | ● | ● | Pumpkin | *Cucurbita maxima* |
| | ● | | ● | Okra | *Abelmoschus* spp. *(esculentus/caillei)* |
| | | ● | ● | Watermelon/Egusi | *Citrullus lanatus/mucosospermus* |
| **Legumes** | | | | African Yam Bean | *Sphenostylis stenocarpa* |
| | | | | Kersting's Groundnut | *Macrotyloma geocarpum* |
| | | | | Lupin | *Lupinus albus* |
| | ● | | | Lablab/Bonavist | *Lablab purpureus* |
| | | | | Fenugreek | *Trigonella foenum-graecum* |
| | | | ● | Fava Bean | *Vicia faba* |
| | ● | | | Grass Pea | *Lathyrus sativus* |
| | | | ● | Lentils | *Lens culinaris* |
| | ● | | ● | Mung Bean/Green Gram | *Vigna radiata* |
| | | | | Chickpea | *Cicer arietinum* |
| | | | | Peas | *Pisum sativum* |
| | ● | | ● | Bambara Groundnut | *Vigna subterranea* |
| | ● | | | Pigeon Pea | *Cajanus cajan* |
| | ● | | ● | Cowpea | *Vigna unguiculata* |
| **Nuts & Oilseeds** | | | | Safflower | *Carthamus tinctorius* |
| | | | | Flax | *Linum usitatissimum* |
| | | | | Macadamia | *Macadamia ternifolia* |
| | | | | Shea | *Vitellaria paradoxa* |
| | | ● | | Allanblackia/Tallow Tree | *Allanblackia floribunda* |
| | ● | | | Sesame | *Sesamum indicum* |
| | | ● | ● | Cashew | *Anacardium occidentale* |
| | ● | | | Groundnut | *Arachis hypogea* |

Table 6
## Opportunity Crop List and Reference Crops for Crops Modeled by AgMIP and Havos.ai in VACS Phase 2 Research

| Crop Group | Common Name | Reference Crop |
|---|---|---|
| **Cereals** | Teff | Maize |
| | Fonio | |
| | Finger Millet | |
| | Sorghum | |
| | Pearl Millet | |
| **Legumes** | Grass Pea | Soybean |
| | Pigeon Pea | |
| | Bambara Groundnut | |
| | Lablab | |
| | Cowpea | |
| | Mung Bean/Green Gram | |
| **Roots & Tubers* (Includes leaves)** | Cocoyam | Cassava (Tubers and leaves) |
| | Yams | |
| | Taro | |
| | Sweet Potato | |
| **Nuts, Seeds & Oilseeds** | Sesame | Soybean |
| | Groundnut | |
| **Fruits & Vegetables** | African Eggplant | Tomato |
| | Okra | |
| | Amaranth | Cassava (Leaves) |

*Yield projections for roots and tubers are based on tuber production and does not consider leaf production. Future modeling work will incorporate leaf production in addition to tuber production.

# **Opportunity Crops** (Annuals/Biennials)


Pearl Millet


Okra


Fonio


Finger Millet


Pigeon Pea


Mung Bean/
Green Gram


Yams


Amaranth


Teff


Sorghum


Bambara Groundnut


Lablab


Sweet Potato


African Eggplant


Grass Pea


Sesame


Groundnut


Cocoyam

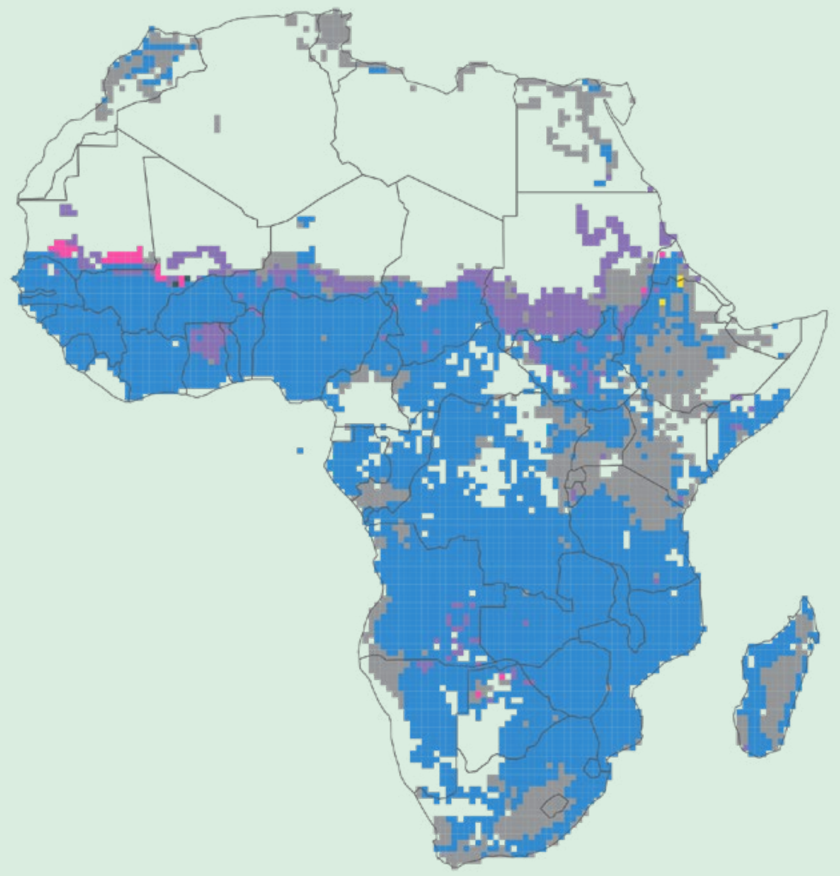

Cowpea


Taro

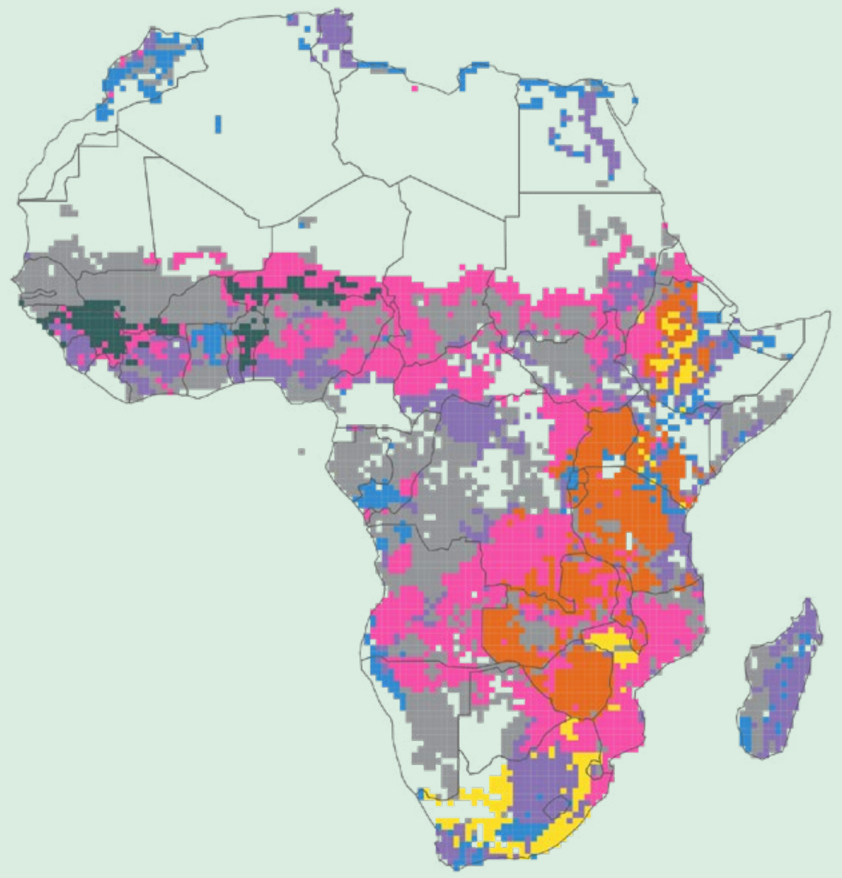

# Summary of Climate-Crop Modeling Results

This figure displays the combined yield change projections for all the cereals that AgMIP has modeled to date. Maize is projected to decrease in productivity in most areas of Africa, and is projected to see the largest relative yield losses of all cereals modeled. A variety of cereal crops are projected to be significantly more climate-resilient than maize across most areas of the continent. Pearl millet projects to be a strong option in many regions across the continent, including in Sahelian zones, with fonio being particularly resilient in West Africa, finger millet in East Africa, and sorghum showing potential in wide range of geographies across the continent.

**Largest Yield Decrease**
SSP3-7.0 – High Emissions



**Largest Yield Increase**
SSP3-7.0 – High Emissions



**Legumes**

| | | | |
|---|---|---|---|
| None | Maize | Fonio | Teff |
| Finger millet | Pearl millet | Sorghum | |

# Fonio *Digitaria exilis*

“Key traits to unlock [fonio’s] potential: 1) Seed Size, 2) Lodging 3) Dwarfing”

*Expert plant breeder*

## Opportunity Crop Profile

Fonio is an ancient and nutritionally rich cereal crop indigenous to West Africa. It is primarily cultivated in countries such as Mali, Burkina Faso, Guinea, and Nigeria, often on small farms for home consumption, covering around 300,000 hectares and feeding 3-4 million people annually.

Fonio thrives on poor, sandy, or ironstone soils, often deemed too infertile for other cereal crops. Fonio grows in varying altitudes, commonly found from sea level up to about 1,000 meters (e.g., Nigeria’s Plateau State and Guinea’s Fouta Djallon plateau). This adaptability extends to its tolerance of different rainfall patterns; it can grow in areas with annual rainfall ranging from 250 mm to 1,500 mm. Fonio is also recognized for its rapid growth and maturation, with certain varieties ready for harvest in as little as 6 to 8 weeks. This quick turnaround is crucial during periods of food scarcity, providing a vital food source when other crops are not yet harvestable. Its rapid growth cycle can naturally reduce the exposure time to certain pests and diseases.

The nutritional profile of fonio is a significant asset, especially its richness in methionine and cystine, that are deficient in many major cereals. This nutritional aspect, coupled with its adaptability and quick maturation, underscores Fonio’s potential for expanded cultivation and recognition as a vital crop in global food security, particularly in regions with challenging agricultural conditions.

### Key Features

- High yielding under current climate
- Climate-resilient yield potential
- Heat-tolerant
- Relative high concentration of Iron
- Cultural significance
- High lean season value
- High Value Chain Potential
- High consumer acceptance
- Water use efficiency (WUE)
- Nutrient use efficiency
- Genomic sequencing completed or underway

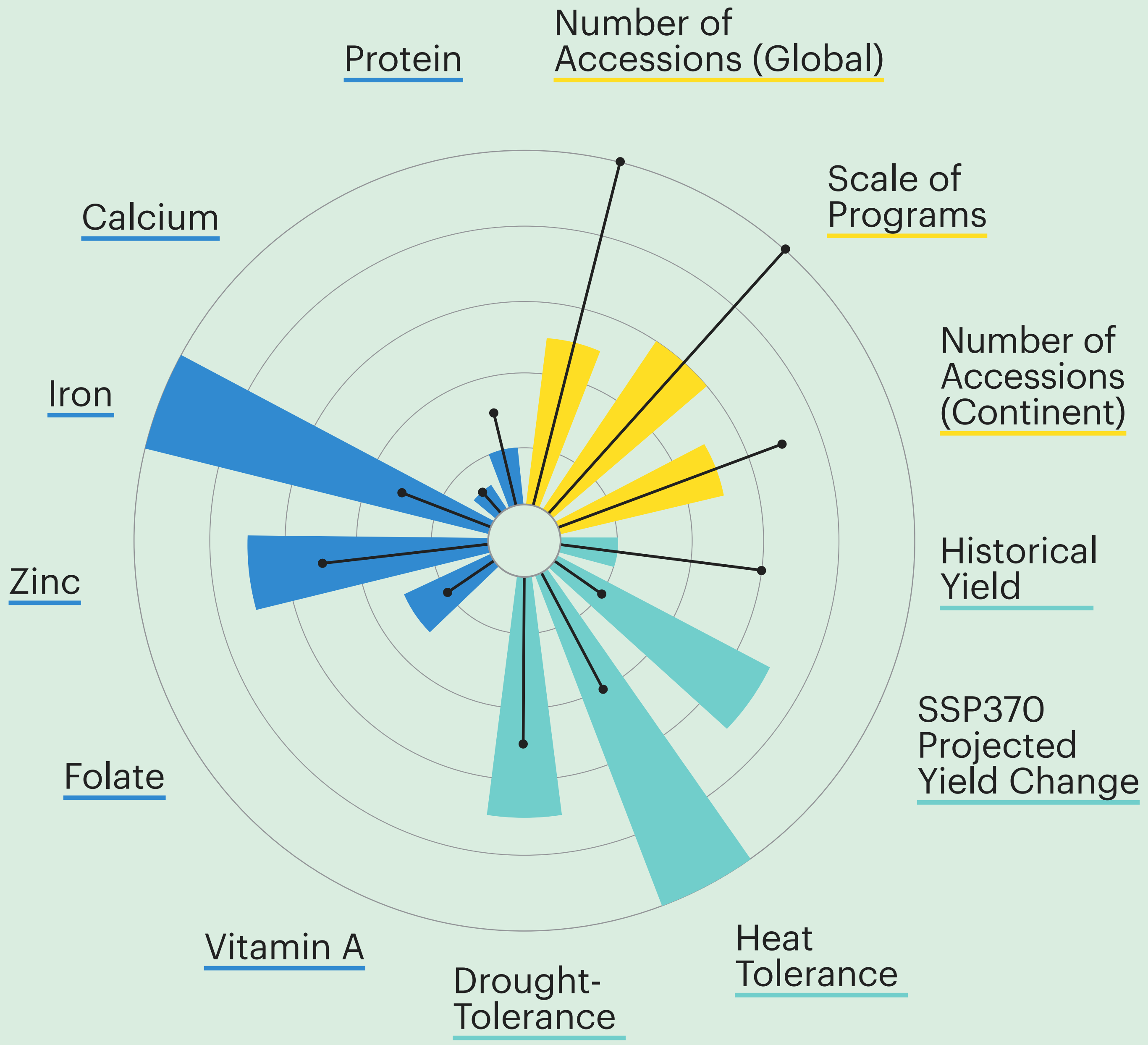
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Fonio

## Climate Change Assessment

Fonio is higher in iron and zinc compared to maize but has lower values of protein, calcium and folate. Fonio has a moderate-to-low amount of global and continental accessions, meaning that expansion of these resources may have a relatively high marginal return on investment. The scale of its programs remains largely national and/or regional. Fonio is drought-tolerant and highly heat-tolerant and is projected to see a positive yield change under climate change conditions. In fact, as seen under both SSP1-2.6 and SSP3-7.0, fonio sees a positive yield change in West Africa, with some minor projected decreases closer to the Sahel.

## Adaptation Indicators




| | |
|---|---|
| Nutritional | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**

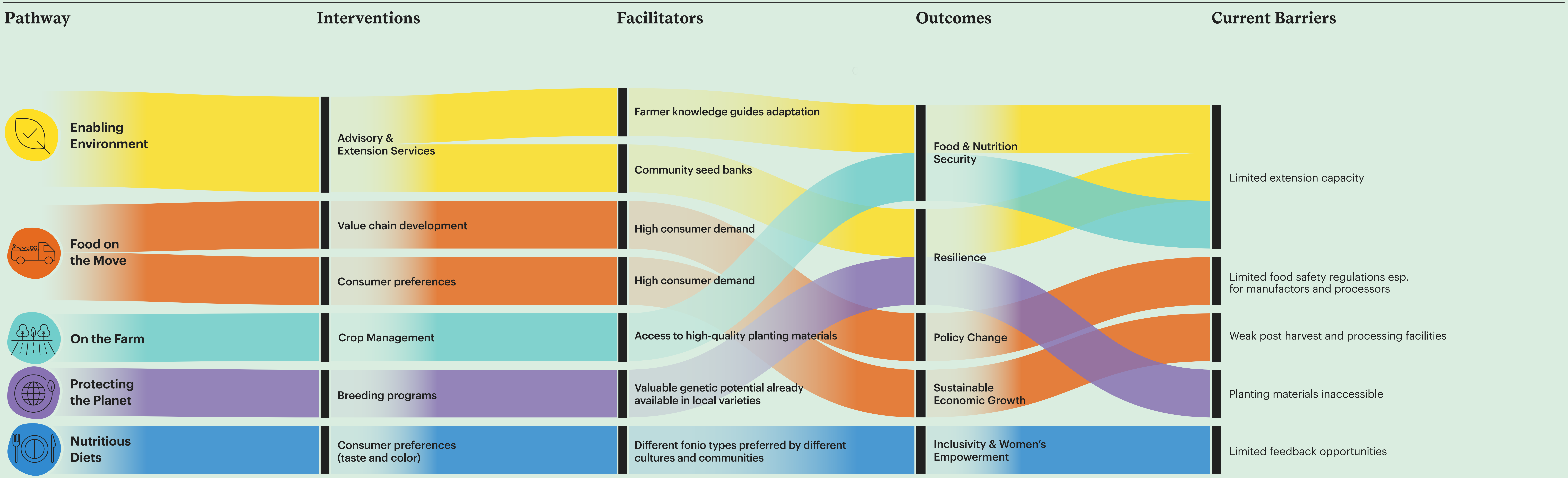
**SSP3-7.0**
**High Emissions**

**% Change in Yield**

# **Fonio** Intervention Pathways

The evidence for fonio indicates a diverse range of outcomes, and a series of interventions supporting those outcomes. There is high consumer demand for fonio in the regions of the world where it is grown, as well as a farmer community that contributes towards its continued growth and development. Value chain development is occurring, but regulatory interventions and improved technologies to support post-harvest processing remain limited.

Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental



# Teff *Eragrostis tef*

> “One challenge of this crop is lodging that reduces yield due to its soft culm/stem, and so far there is no naturally available strong culm/stem variant for breeding… effort is being made to improve this trait through gene editing.”
>
> *Expert plant breeder*

## Opportunity Crop Profile

Teff is a cereal crop indigenous to the highlands of Ethiopia and Eritrea, characterized by its small seeds and high adaptability to various environmental conditions. It is a staple food in these regions, primarily utilized in the preparation of injera, a traditional flatbread.

Teff exhibits significant resilience across a range of soil types and climatic conditions. It is capable of growing in both waterlogged and drought-prone soils, demonstrating a broad ecological plasticity. This adaptability extends to a wide altitudinal range, with successful cultivation occurring from near sea level in Eritrea to elevations exceeding 2,500 meters in the Ethiopian Highlands. Teff’s growth cycle is relatively short, typically spanning 90 to 120 days, which facilitates its cultivation within diverse agroecological zones and farming systems within its native regions.

Nutritionally, teff is notable for its composition. It is a source of dietary fiber, protein, and essential micronutrients such as iron, calcium, and magnesium. The absence of gluten in teff grains makes them suitable for gluten-free diets, a feature that is increasingly sought after in global health food markets.

## Key Features

- High yielding under current climate
- Climate-resilient yield potential
- Heat-tolerant
- Disease-resistant
- Supports animal and livestock health
- Drought-tolerant
- Cultural significance
- Relative high concentration of Zinc
- High Value Chain Potential
- High consumer acceptance
- Water use efficiency (WUE)
- Nutrient use efficiency
- Genomic sequencing completed or underway
- High plant genetic resources in Africa

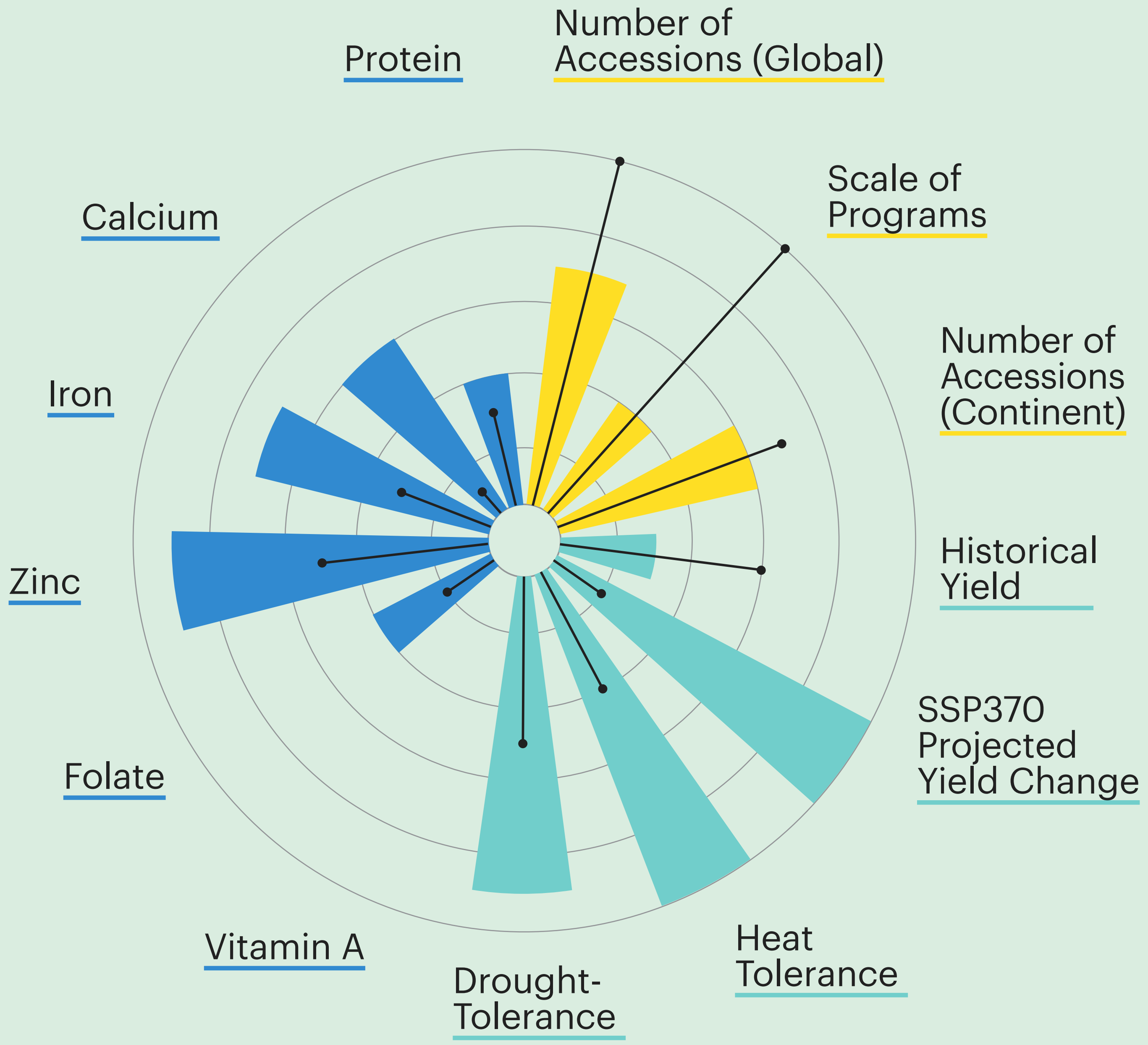
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Teff

## Climate Change Assessment

Teff has relatively high levels of micronutrients such as zinc, iron, and calcium, and moderate levels of protein and folate, exceeding the reference crop maize in every category. Teff has a moderate-to-low amount of global and continental accessions. The scale of its breeding programs remains largely at the national level. Teff is highly drought-tolerant and heat-tolerant and is expected to see a significant positive projected yield change under climate change conditions. In fact, as seen under both SSP1-2.6 and SSP3-7.0, teff sees average positive yield changes across both Eastern and Southern Africa.

## Adaptation Indicators




| | |
|---|---|
| Nutritional/Sociocultural | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

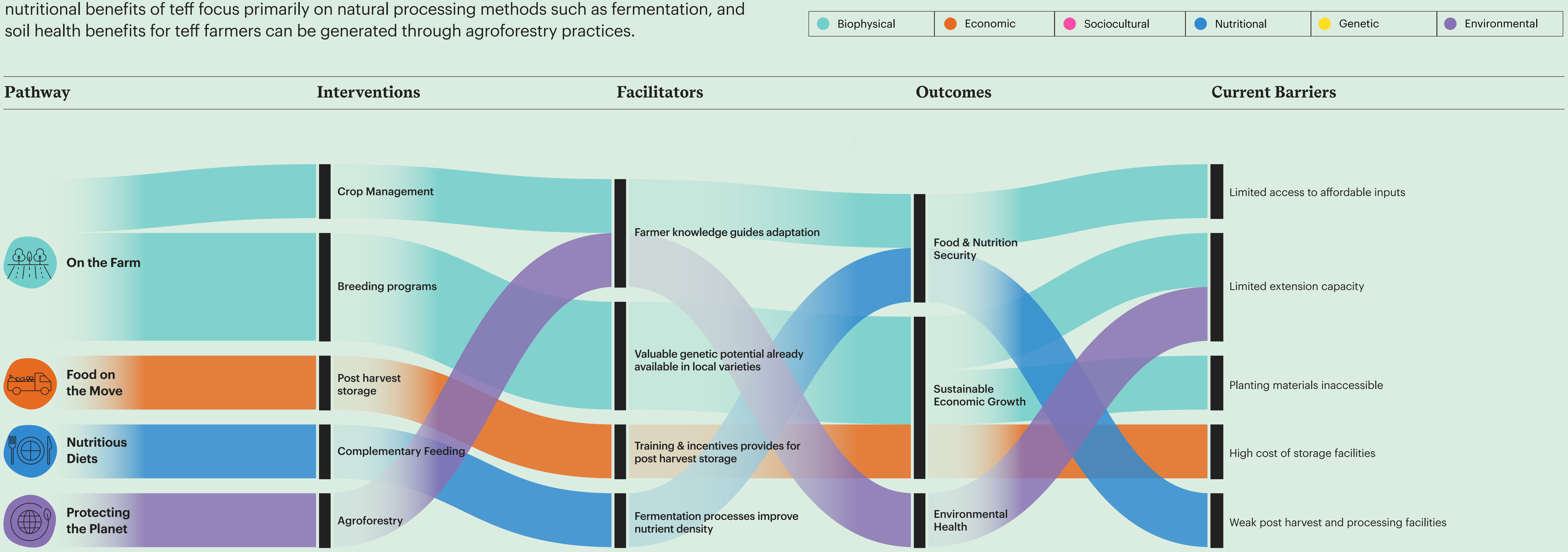
**SSP1-2.6**
**Low Emissions**

**SSP3-7.0**
**High Emissions**

**% Change in Yield**

# Teff Intervention Pathways

High-quality evidence on teff includes interventions to support crop management enhancements, including new varietal development. Best practices to increase resilience, environmental health, and crop yield are delivered through advisory and extension services. Overall, evidence to support nutritional benefits of teff focus primarily on natural processing methods such as fermentation, and soil health benefits for teff farmers can be generated through agroforestry practices.



# Sorghum *Sorghum bicolor*

“Drought tolerant and [important] food security crop... [there is already] extensive breeding activities for this crop at national, regional and international level”

*Expert plant breeder*

## Opportunity Crop Profile

Sorghum is extensively cultivated in regions like Western and Eastern Africa (e.g. Nigeria, Chad, Ethiopia, and Sudan), and in the southern parts of the continent, including nations like South Africa and Zimbabwe. Globally, it ranks just below rice, wheat, maize, and potatoes in terms of consumption. Sorghum boasts a wide genetic diversity, presenting a range of grain types and adaptabilities that hold research potential.

Sorghum thrives in a variety of climates, from temperate to tropical. It is highly efficient in photosynthesis and can mature rapidly, with some varieties ready for harvest in as little as 75 days. Its resilience is particularly valuable in arid and semi-arid regions of Africa, where it withstands extreme conditions that are challenging for other major grains. Apart from its role as a staple food grain, sorghum also finds applications in producing sugar, syrup, alcohol fuels, and other industrial products. It is cultivated through diverse farming methods, ranging from small-scale, traditional farming to large-scale commercial agriculture.

Sorghum’s ability to adapt to less fertile and drier lands positions it as a critical crop for future food security, especially in the tropics and subtropics. Leveraging its genetic diversity for breeding improved varieties could enhance yield and quality, addressing food security challenges. Increased research and development efforts, akin to those dedicated to other major cereals, could further unlock sorghum’s potential, making it a more substantial contributor to global agricultural sustainability and food supplies.

## Key Features

- Climate-resilient yield potential
- Heat-tolerant
- Supports animal and livestock health
- Cultural significance
- High Value Chain Potential
- High consumer acceptance
- High plant genetic resources globally
- High plant genetic resources in Africa
- Genomic sequencing completed or underway

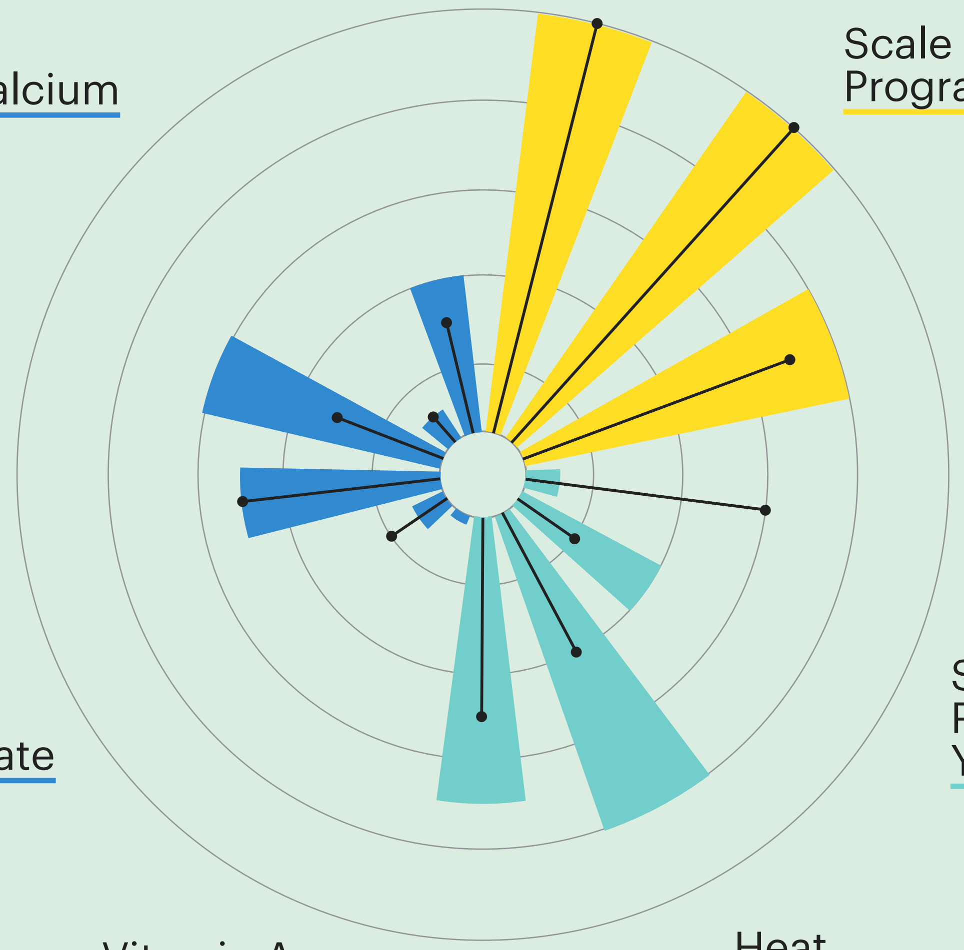
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Sorghum

## Climate Change Assessment

Sorghum has moderate concentrations of iron, zinc, and protein and is relatively low in folate, calcium, and vitamin A levels. It is comparable to maize in many of the nutritional indicators analyzed, except it has notably higher iron content. Sorghum is highly invested in globally, with high numbers of available accessions and breeding programs across the globe. Sorghum is highly drought-tolerant and extremely heat-tolerant, but its resilience under climate change conditions is mixed and regionally dependent. In fact, as seen under both SSP1-2.6 and SSP3-7.0, sorghum sees a negative yield change near the Western Sahel and in parts of West Africa but a positive yield change in parts of North, Central and Southern Africa.

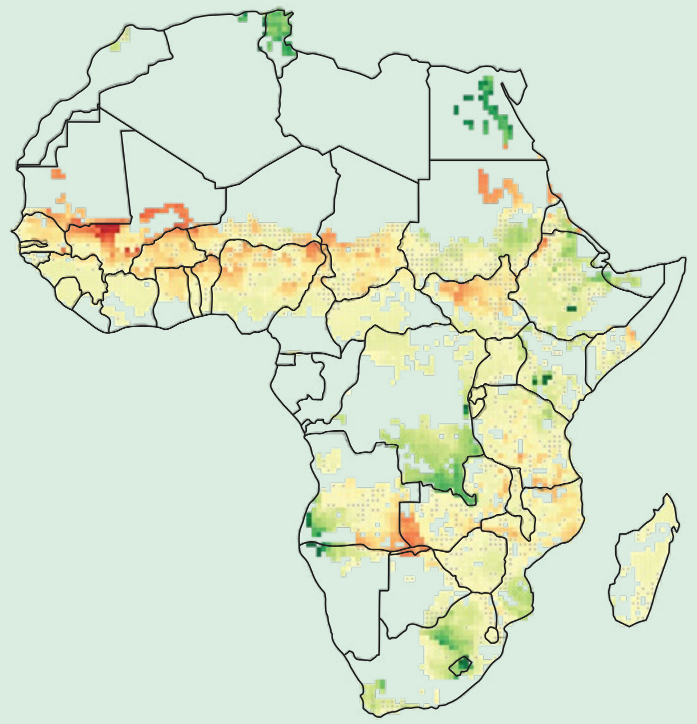
## Adaptation Indicators



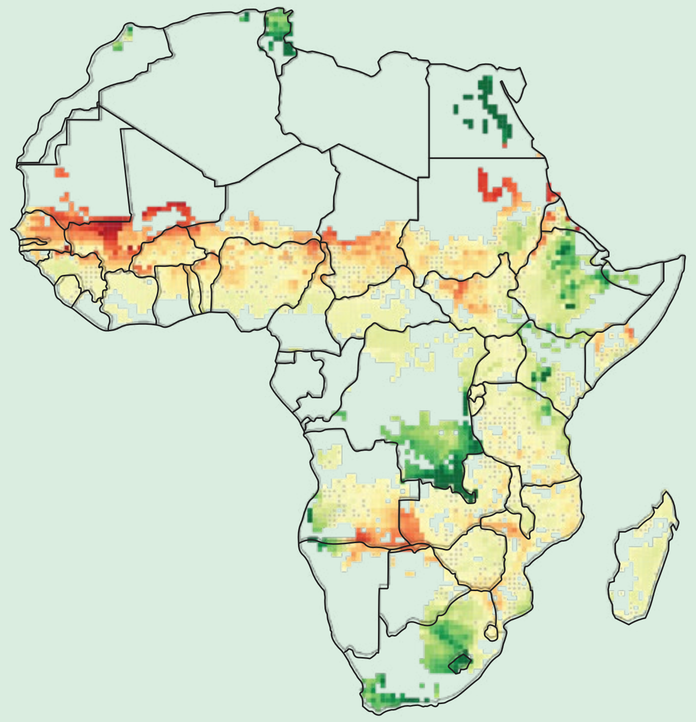

| | |
|---|---|
| Nutritional/Sociocultural | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**

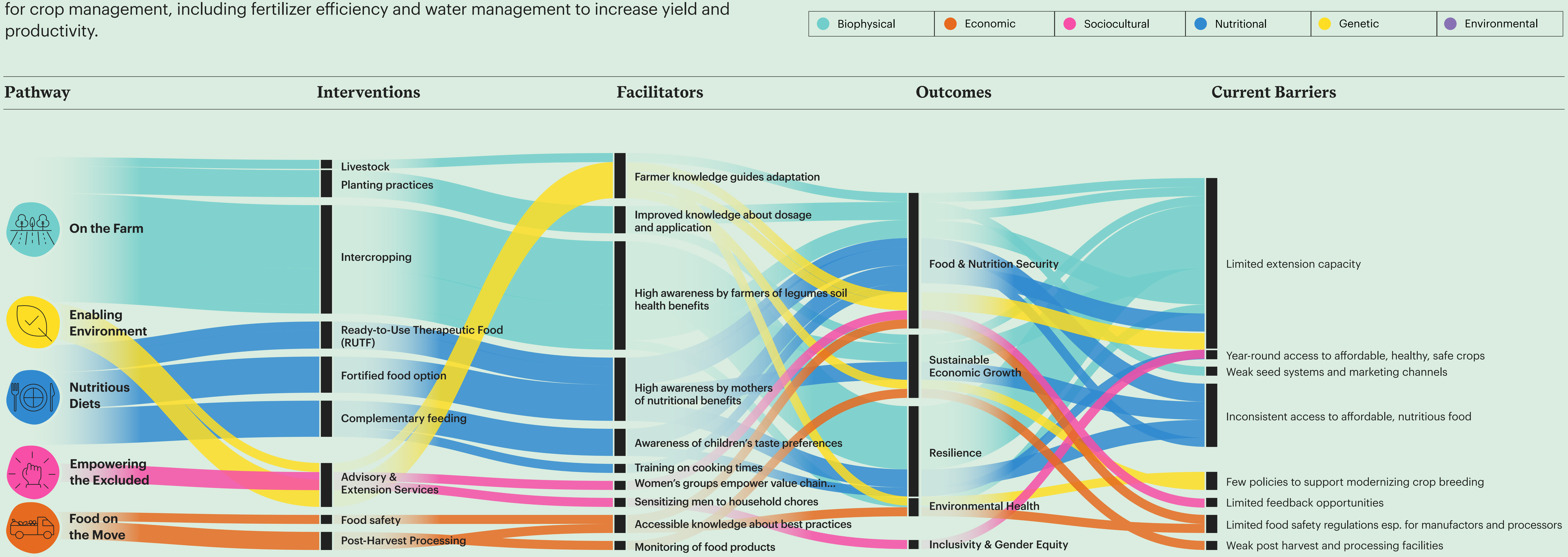


**% Change in Yield**

Model disagreement — 50 — 25 — 0 — -25 — -50

# **Sorghum** Intervention Pathways

Sorghum presents multiple opportunities to increase food security & nutrition for rural communities, especially children. High-quality evidence supports complementary feeding programs, food fortification, and therapeutic food interventions. These interventions depend on having high-quality and food safe sorghum year-round. Communities also benefit from advisory and extension services for crop management, including fertilizer efficiency and water management to increase yield and productivity.



# Finger Millet
## *Eleusine coracana*

> **“Excellent [potential] given focused and coordinated breeding programs. Plant Genetic Resources (PGR) are available and it’s a good candidate for climate change adaptation.”**
>
> *Expert plant breeder*

### Opportunity Crop Profile

Finger millet is an established crop in parts of East and Central Africa, and also in India. It is commonly cultivated in countries like Uganda, Kenya, Tanzania, Malawi, Zimbabwe and Ethiopia, especially in subhumid upland areas. This grain is notable for its high nutritional value, particularly its methionine content. It adapts well to marginal lands, and its grains have a long storage life and are resistant to insect damage. Despite its beneficial qualities and consumer preference, finger millet has received less research focus compared to other major cereals like wheat, rice, and maize.

Finger millet is a tufted annual that grows to a height of 40-130 cm and matures within 2.5 to 6 months. It adapts to a range of environmental conditions, flourishing under a short-day photoperiod and typically within 20°N and 20°S latitude. It requires moderate rainfall for growth and can withstand temperatures as high as 35°C. This crop is often found at altitudes ranging from 500 to 2,400 meters and can grow in various soil types, including reddish-brown lateritic soils with good drainage and water-holding capacity. The crop’s labor requirements for planting, weeding, and processing have influenced its cultivation practices.

### Key Features

- High yielding under current climate
- Climate-resilient yield potential
- Heat-tolerant
- Disease-resistant
- Supports animal and livestock health
- Drought-tolerant
- Relative high concentration of Calcium
- Relative high concentration of Iron
- High lean season value
- High consumer acceptance
- Genomic sequencing completed or underway
- High plant genetic resources in Africa

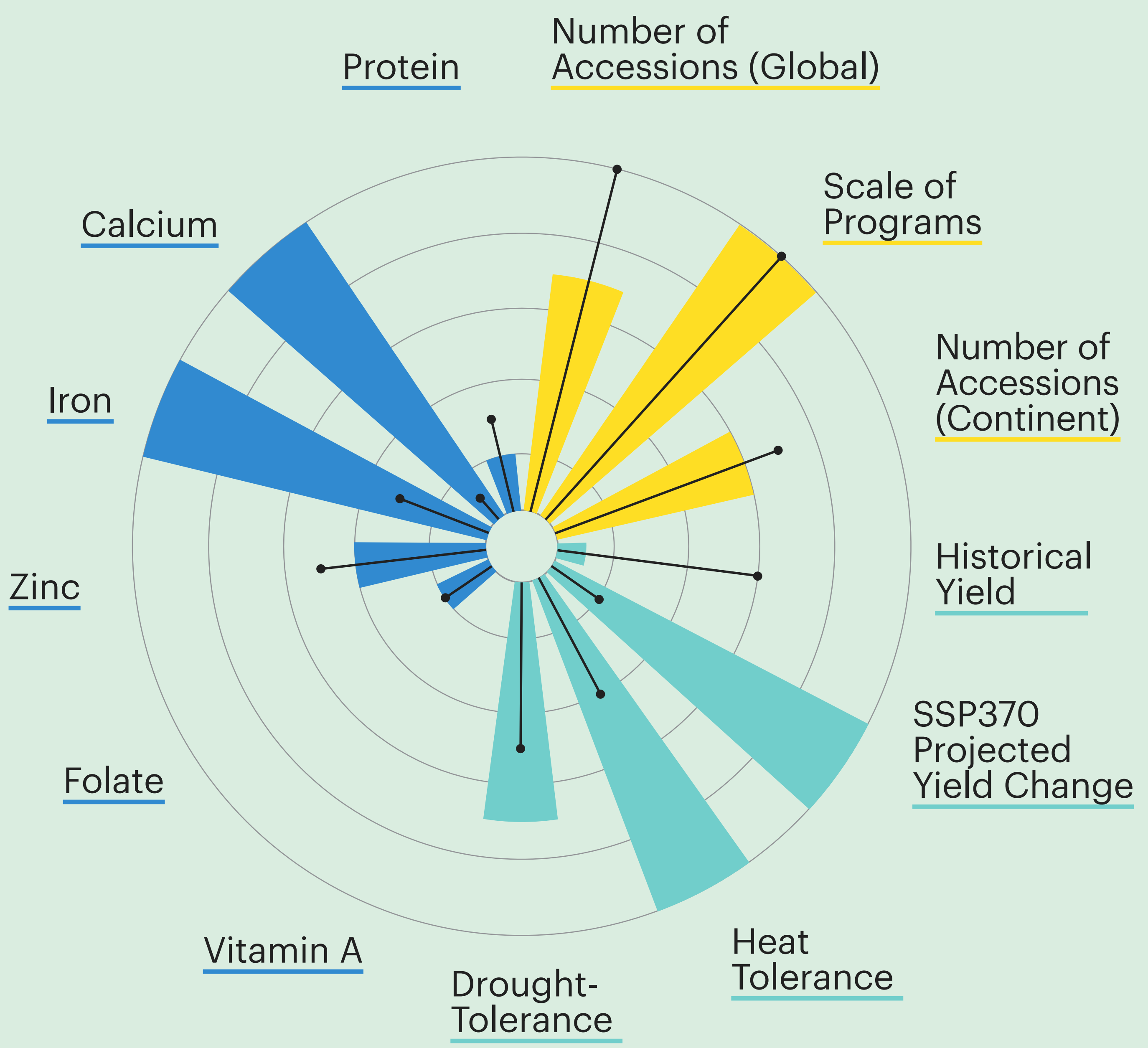
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Finger Millet

## Climate Change Assessment

Finger millet shows a much higher values for iron and calcium than maize, though zinc and protein content is lower. Finger millet has received a relatively high level of global investment, as seen by the scale of breeding programs and number of global accessions. However, continent-wide accessions are moderate and more regionally-specific. Finger millet is drought-tolerant and extremely heat-tolerant, resulting in an overwhelming positive projected yield change under climate change in most regions. However, it is important to note that finger millet baseline historical yields are extremely low, so while yield change projections are significant as a percentage of historical yield, the absolute projected yields are still not as high as many other cereals.

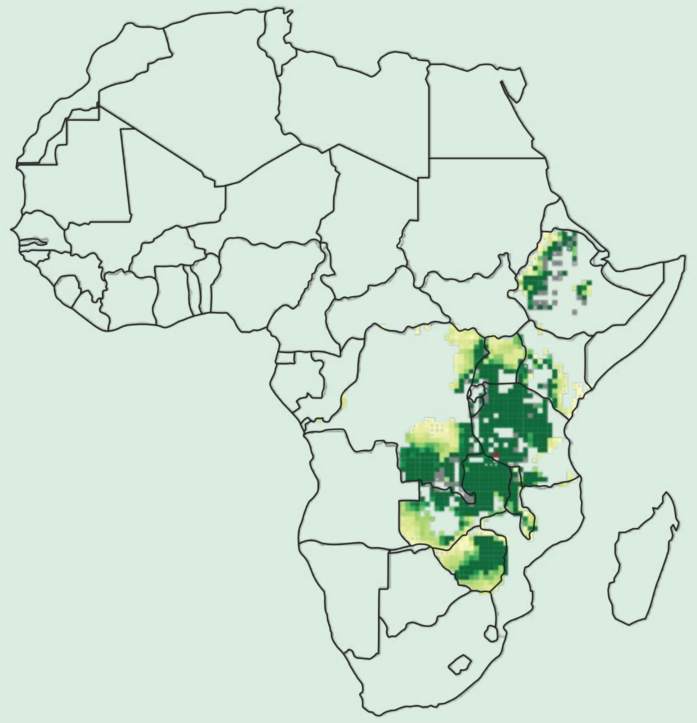
## Adaptation Indicators



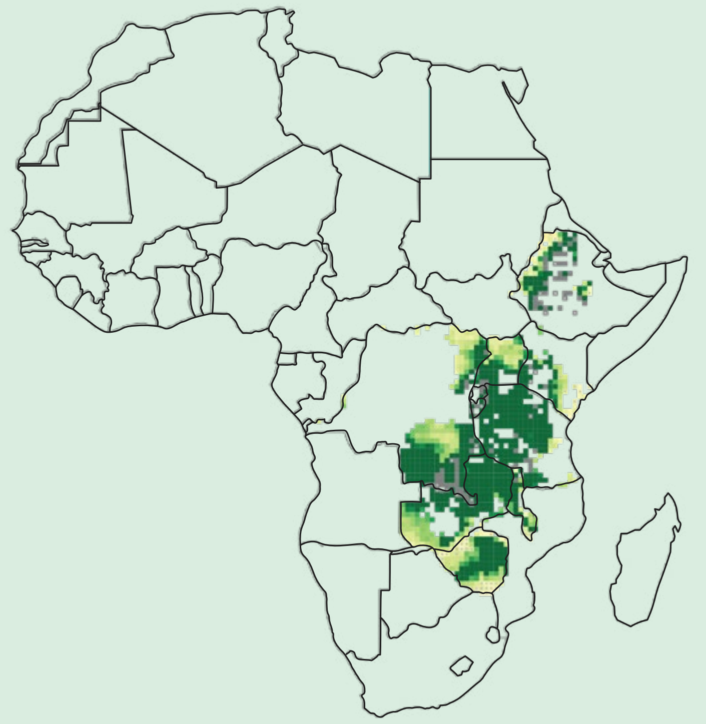

| | |
|---|---|
| Nutritional/Sociocultural | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**

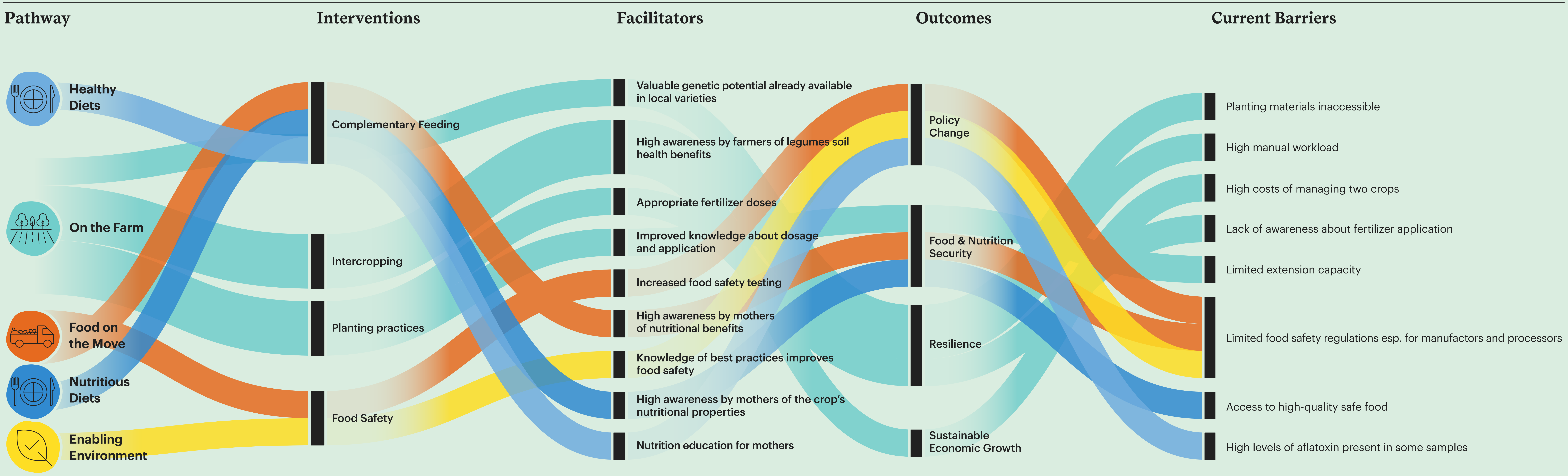


**% Change in Yield**

# **Finger Millet** Intervention Pathways

Interventions supporting finger millet emphasize on-farm management, including guidance on intercropping, pesticide and input management, and exploring genetic potential across local varieties. And, across all cereal crops including finger millet, concerns about aflatoxin contamination are raised. Often, contamination is identified through testing of market-available grain. Addressing this requires food safety interventions at the regulatory and policy level. Finger millet is also appreciated by mothers and caregivers as highly nutritious.

| Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental |
|---|---|---|---|---|---|



# Pearl Millet *Cenchrus americanus/Pennisetum glaucum*

## Opportunity Crop Profile

Pearl Millet is a vital cereal crop that originated from a wild West African grass and was domesticated over 4,000 years ago. It is widely cultivated in areas across the African Continent.

Pearl millet is resilient in extreme conditions, thriving on poor soils often considered unfit for other cereal crops. Its adaptability is evident as it grows in various altitudes, from the lowlands to areas exceeding 1,200 meters in different regions. This resilience is particularly valuable in arid and semi-arid zones, where it can grow in regions receiving rainfall ranging from 200 mm to 1,500 mm annually. The crop's ability to mature quickly, typically within 70 to 90 days, makes it an essential resource during periods of food scarcity, helping bridge gaps in food availability with its rapid growth cycle.

The nutritional value of pearl millet offers a higher protein content than many grains and a balance of essential amino acids, alongside significant levels of important micronutrients such as zinc, magnesium, and iron.

**"Pearl millet requires less moisture and thrives well in marginal soils as well as high temperatures."**

*Expert plant breeder*

## Key Features

- Climate-resilient yield potential
- Drought-tolerant
- Heat-tolerant
- Pest-resistant
- Disease-resistant
- High consumer acceptance
- High Value Chain Potential
- High lean season value
- Relative high concentration of Iron
- Relative high concentration of Zinc
- Cultural significance
- Water use efficiency (WUE)
- High plant genetic resources globally
- High plant genetic resources in Africa
- Genomic sequencing completed or underway

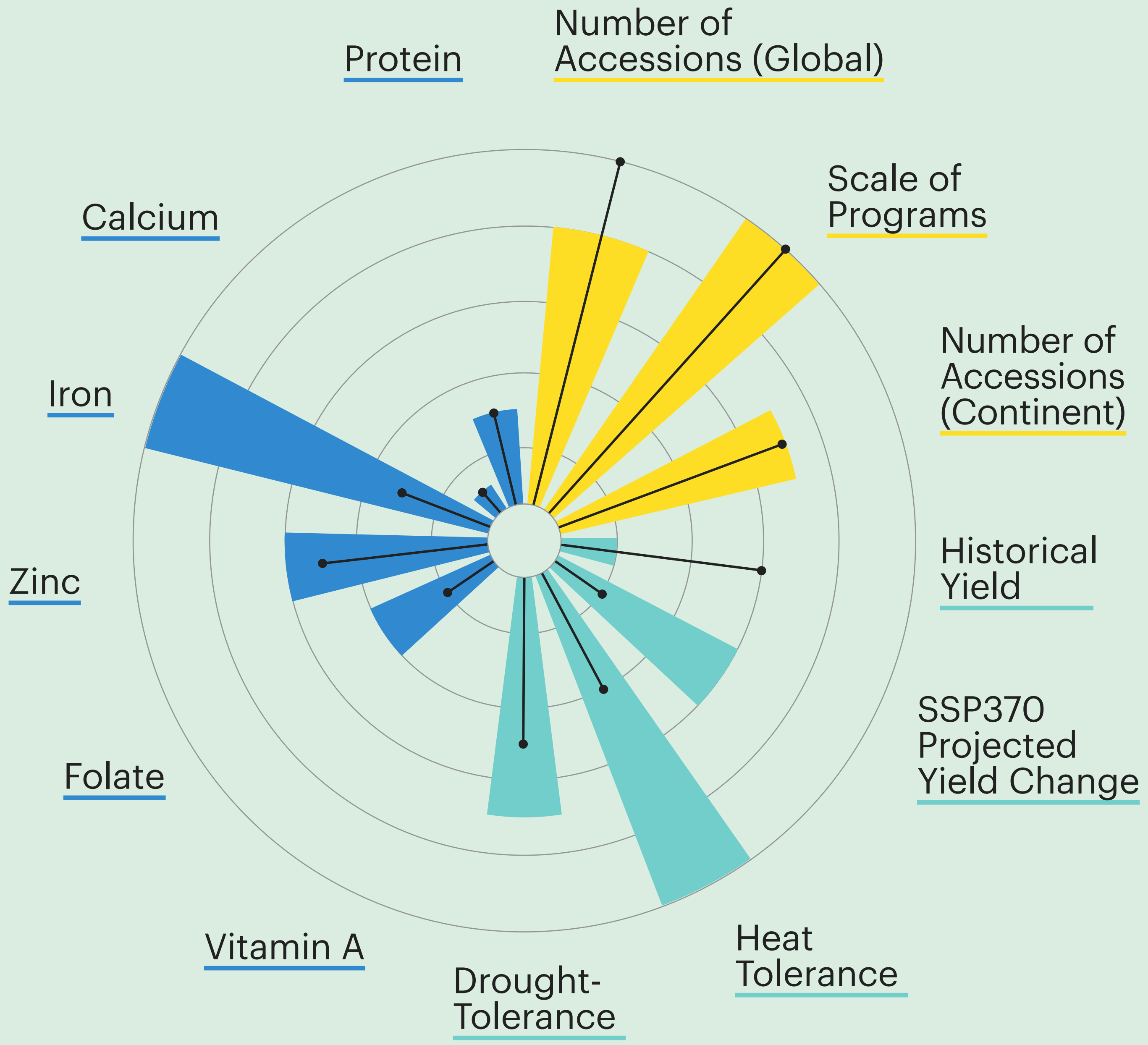
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Pearl Millet

## Climate Change Assessment

Pearl Millet is rich in micronutrients such as iron and zinc but is similar to maize with lower levels of calcium and folate. Pearl Millet has a relatively high number of global and continental accessions, and the scale of its breeding programs are extensive. Pearl Millet is both drought- and heat-tolerant and is projected to see a slight positive relatively yield change under climate change conditions. In fact, as seen under both SSP1-2.6 and SSP3-7.0, Pearl Millet is projected to experience a positive yield change in Western Africa and, more significantly, in Central and Southern Africa.

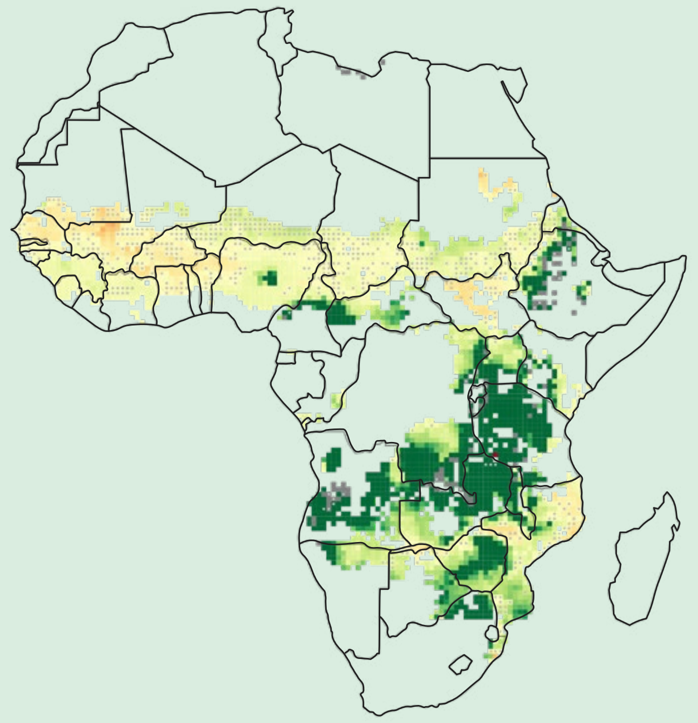
## Adaptation Indicators



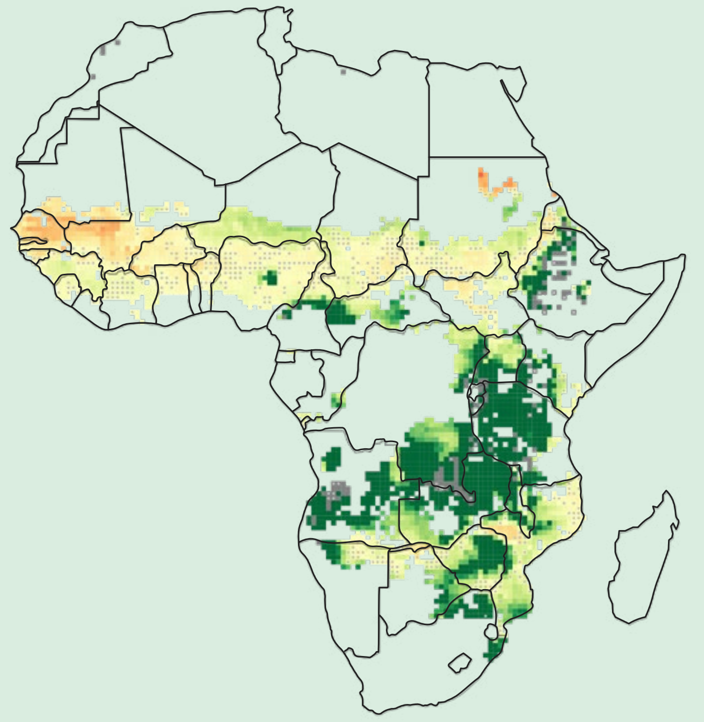

| | |
|---|---|
| Nutritional/Sociocultural | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**



**% Change in Yield**

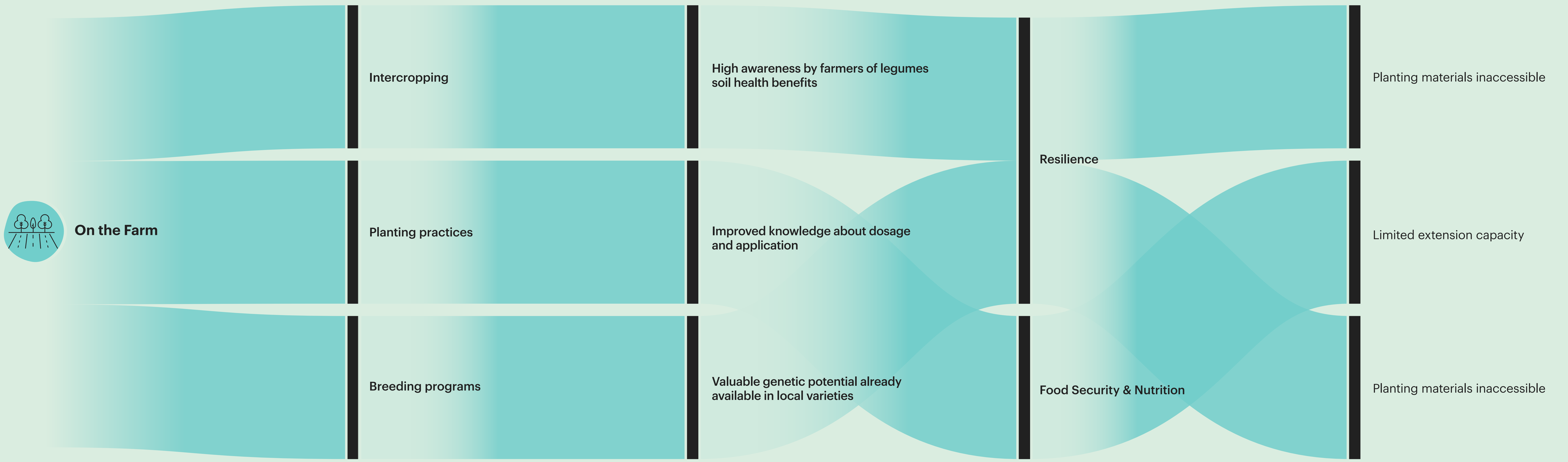
Model disagreement | 50 | 25 | 0 | -25 | -50

# **Pearl Millet** Intervention Pathways

Interventions supporting finger millet emphasize on-farm management, including guidance on intercropping, pesticide and input management, and exploring genetic potential across local varieties. And, across all cereal crops including finger millet, concerns about aflatoxin contamination are raised. Often, contamination is identified through testing of market-available grain. Addressing this requires food safety interventions at the regulatory and policy level. Finger millet is also appreciated by mothers and caregivers as highly nutritious.

| Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental |
|---|---|---|---|---|---|

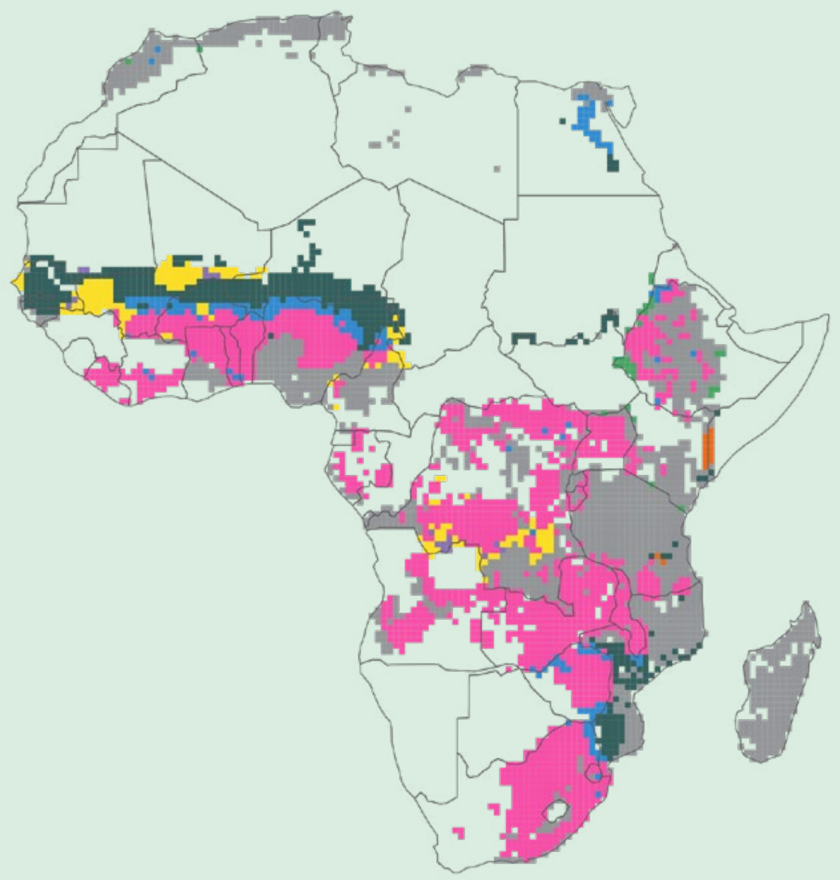
| Pathway | Interventions | Facilitators | Outcomes | Barriers to scaling up |
|---|---|---|---|---|



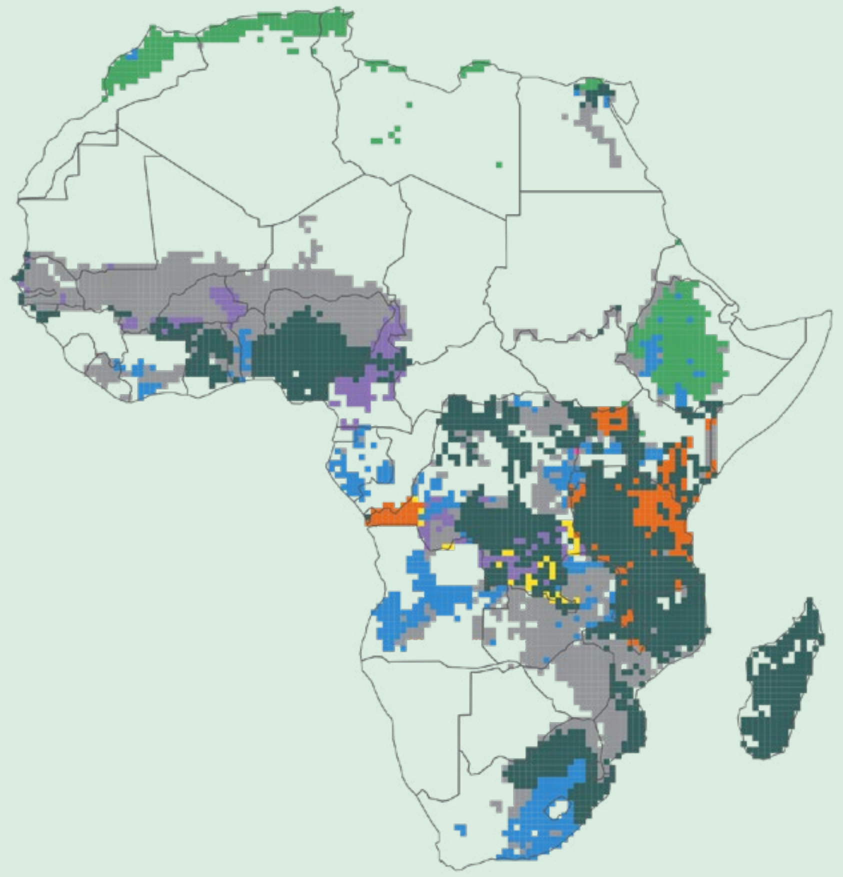

## Summary of Climate-Crop Modeling Results

This figure displays the combined yield change projections for all the legumes that AgMIP has modeled to date. Lablab is projected to decrease in productivity in many areas across the continent and is projected to see the largest relative yield losses of all cereals modeled. A mix of crops are projected to be more resilient on average across the continent depending on geographical context, with grass pea being particularly resilient in parts of East and North Africa, Cowpea poised to be a resilient option in many areas in West and Central africa, and Bambara Groundnut and Pigeon Pea showing high resilience across a range of localized contexts.

**Largest Yield Decrease**
SSP3-7.0 – High Emissions



**Largest Yield Increase**
SSP3-7.0 – High Emissions



**Legumes**

| | | | |
|---|---|---|---|
| None | Soybean | Cowpea | Grass pea |
| Mung bean | Pigeon pea | Lablab | Bambara Groundnut |

# Cowpea *Vigna unguiculata*

## Opportunity Crop Profile

Cowpea, a key legume crop, exhibits a notable resilience to changing climatic conditions. Cowpea is able to maintain yields under increased climate variability and compared to other legumes, cowpea demonstrates high tolerance to flood and pest pressures, as well as resilience to water and heat stress. However, it does face challenges regarding yield loss during storage, a critical factor in post-harvest management.

Predominantly cultivated in Western Africa, cowpea is a significant cash crop for smallholder farmers, particularly women, playing a crucial role in regional economies. The versatility of cowpea, available in dry, pod, and husk forms, makes it an affordable and accessible food source for consumers. Cowpeas are rich in protein and other essential nutrients, making them a valuable dietary component in regions where protein sources may be scarce or expensive.

Cowpea is often utilized as a cover crop, employed in intercropping systems to enhance soil fertility. Its ability to fix nitrogen effectively contributes to improved soil health and can reduce the need for synthetic fertilizers. Cowpea is comparatively less effective than some other legumes in weed suppression, erosion control, and certain aspects of soil health improvement. Cowpea cultivation represents a balance of environmental adaptability, nutritional value, and agronomic challenges, making it a crop of considerable importance in sustainable agriculture systems, particularly in the context of climate change and food security in Africa.

**"[Cowpea is] highly nutritious, multipurpose, plenty of [plant genetic resources] available, [and it] complements most cereals as food."**

*Expert plant breeder*

## Key Features

- Relative high concentration of protein
- Relative high concentration of folate
- High lean season value
- Relative high concentration of Zinc
- Cultural significance
- Contributes to soil health
- Water use efficiency (WUE)
- Nutrient use efficiency
- High consumer acceptance
- High Value Chain Potential
- Genomic sequencing completed or underway
- High plant genetic resources in Africa
- Heat-tolerant

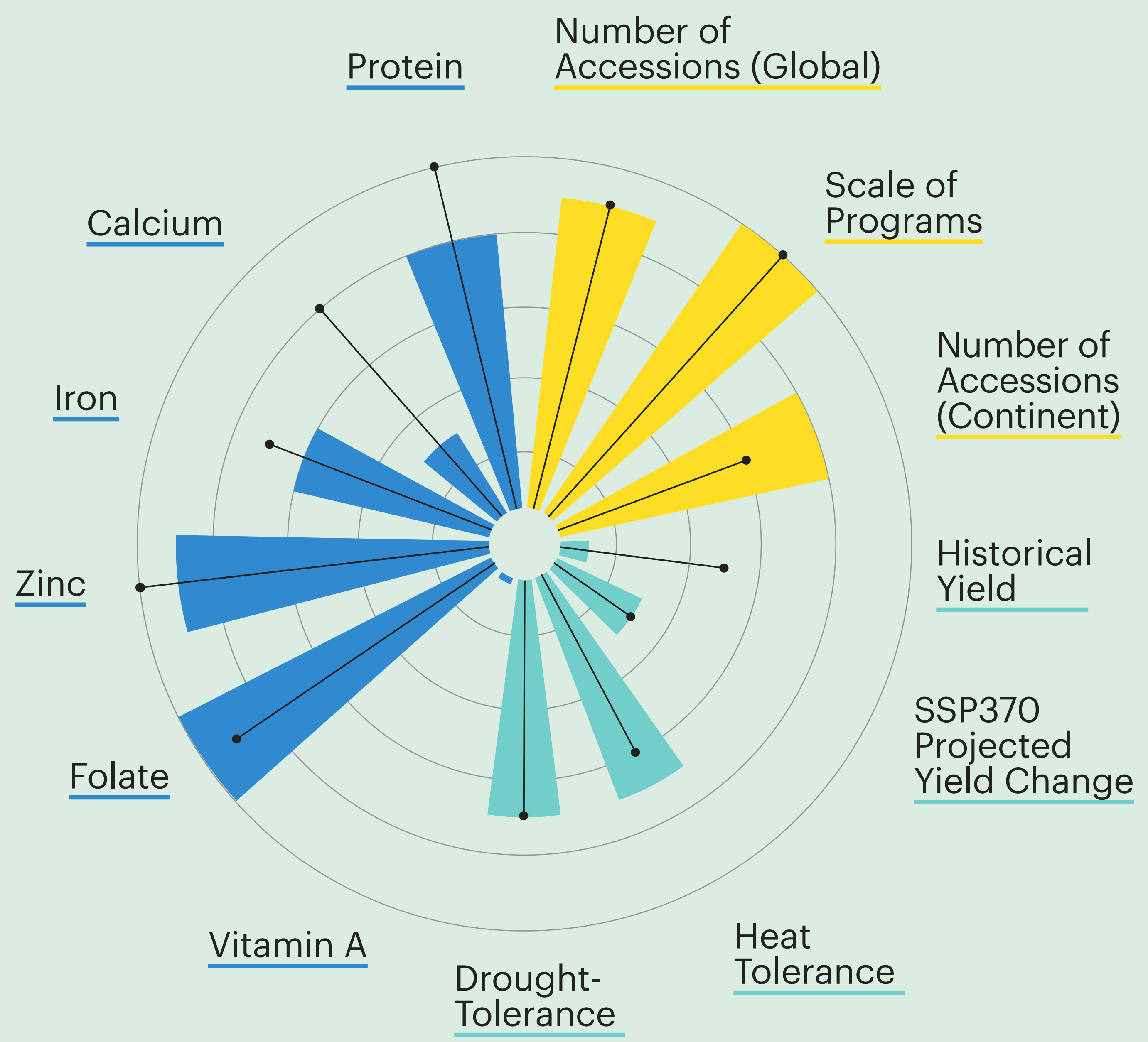
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Cowpea

## Climate Change Assessment

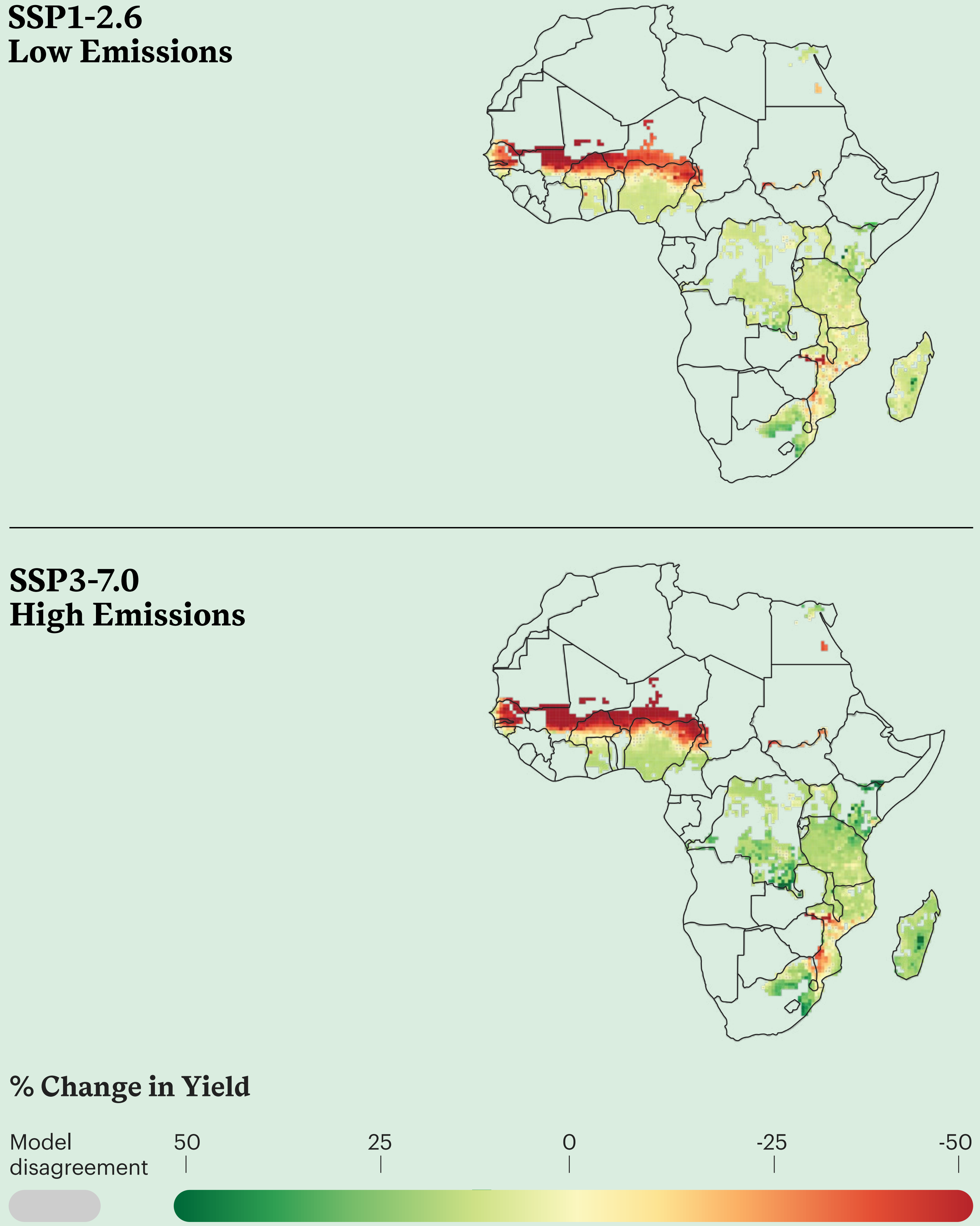
Cowpea is higher in folate and zinc, though has lower iron, calcium and protein content compared to soybean. It is low in calcium and has trace elements of vitamin A. Cowpea is a well-researched crop globally and has a comparable number of accessions as soybean. In fact, it has more accessions than soybean at the continental level. Cowpea is moderately drought and heat-tolerant and its yield change projections vary widely depending on geographical context. It is projected to see a significant reduction in projected yield in areas of West Africa, as seen under both SSP1-2.6 and SSP3-7.0, with slight increases across Central, Eastern, and Southern Africa with some variation in the Southeast of the continent.

## Adaptation Indicators

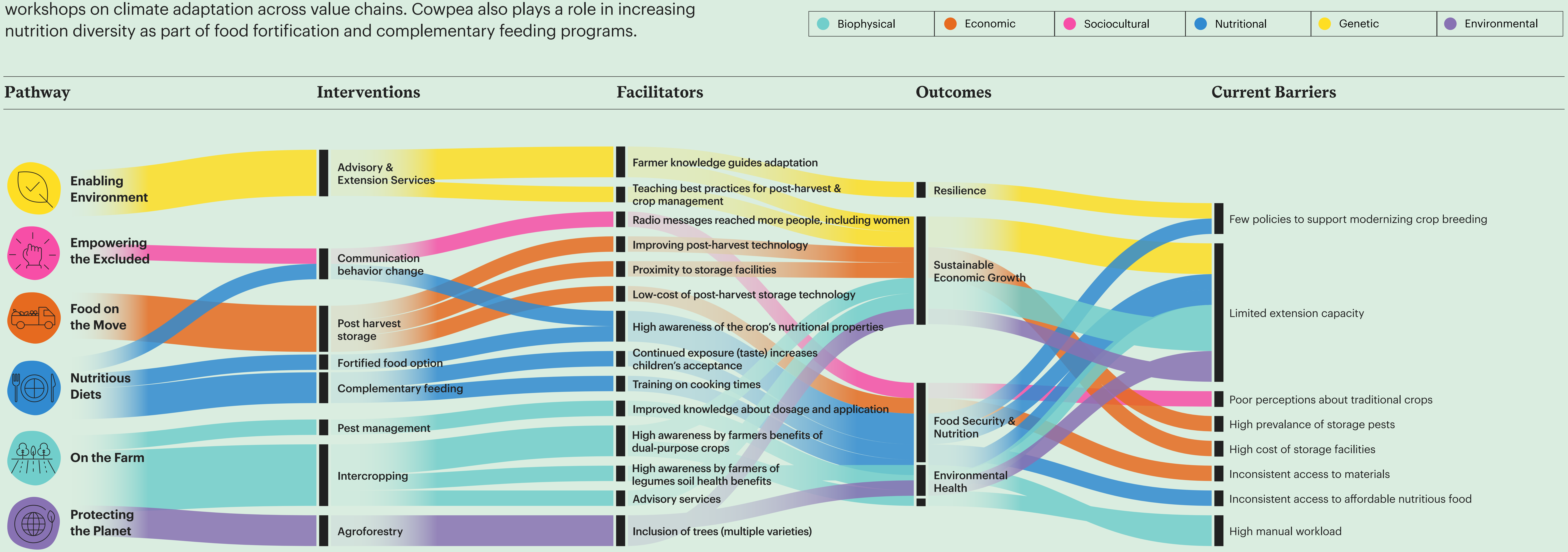



| | |
|---|---|
| Nutritional | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change



Food and nutrition security targets for cowpea are enhanced through increased access to advisory and extension services to support crop management, especially around intercropping with grains and other plants, including trees. These services describe the importance of knowledge sharing workshops on climate adaptation across value chains. Cowpea also plays a role in increasing nutrition diversity as part of food fortification and complementary feeding programs.



# Grass Pea *Lathyrus sativus*

## Opportunity Crop Profile

Grass pea is largely grown in Northern and Eastern Africa (e.g., Eritrea and Ethiopia). This legume is well-suited to environments with extreme climatic conditions, notably areas prone to drought and poor soil quality. Its capacity to withstand water logging also makes it a viable crop in regions experiencing erratic rainfall patterns. This adaptability is crucial in regions where climate variability and soil degradation pose significant challenges to agriculture.

Grass peas' deep root system enables efficient water usage and contributes to soil stabilization, aiding in erosion control. As a legume, it enhances soil fertility through nitrogen fixation, thereby reducing the dependency on chemical fertilizers and promoting sustainable farming practices. However, one significant concern with grass pea is the presence of a neurotoxic compound, β-ODAP, particularly in its seeds.

Its cultivation is particularly notable in Ethiopia, where it serves as both a dietary staple and a safety net crop for smallholder farmers in marginal environments. The future of grass pea in Africa, particularly in enhancing its safety profile and agronomic benefits, holds the potential for improving food security and advancing sustainable agricultural practices in regions facing harsh environmental challenges.

**"Needs breeding for low ODAP content seeds for food. [Produces] high biomass for animal feeding...wild species (i.e. L. cicera, L. gorgoni, etc.,) show resistance to parasitic weeds."**

*Expert plant breeder*

### Key Features

- Climate-resilient yield potential
- Drought-tolerant
- Disease-resistant
- Pest-resistant
- Relative high concentration of protein
- Relative high concentration of folate
- High lean season value
- Relative high concentration of Zinc
- Contributes to soil health
- Water use efficiency (WUE)
- Nutrient use efficiency

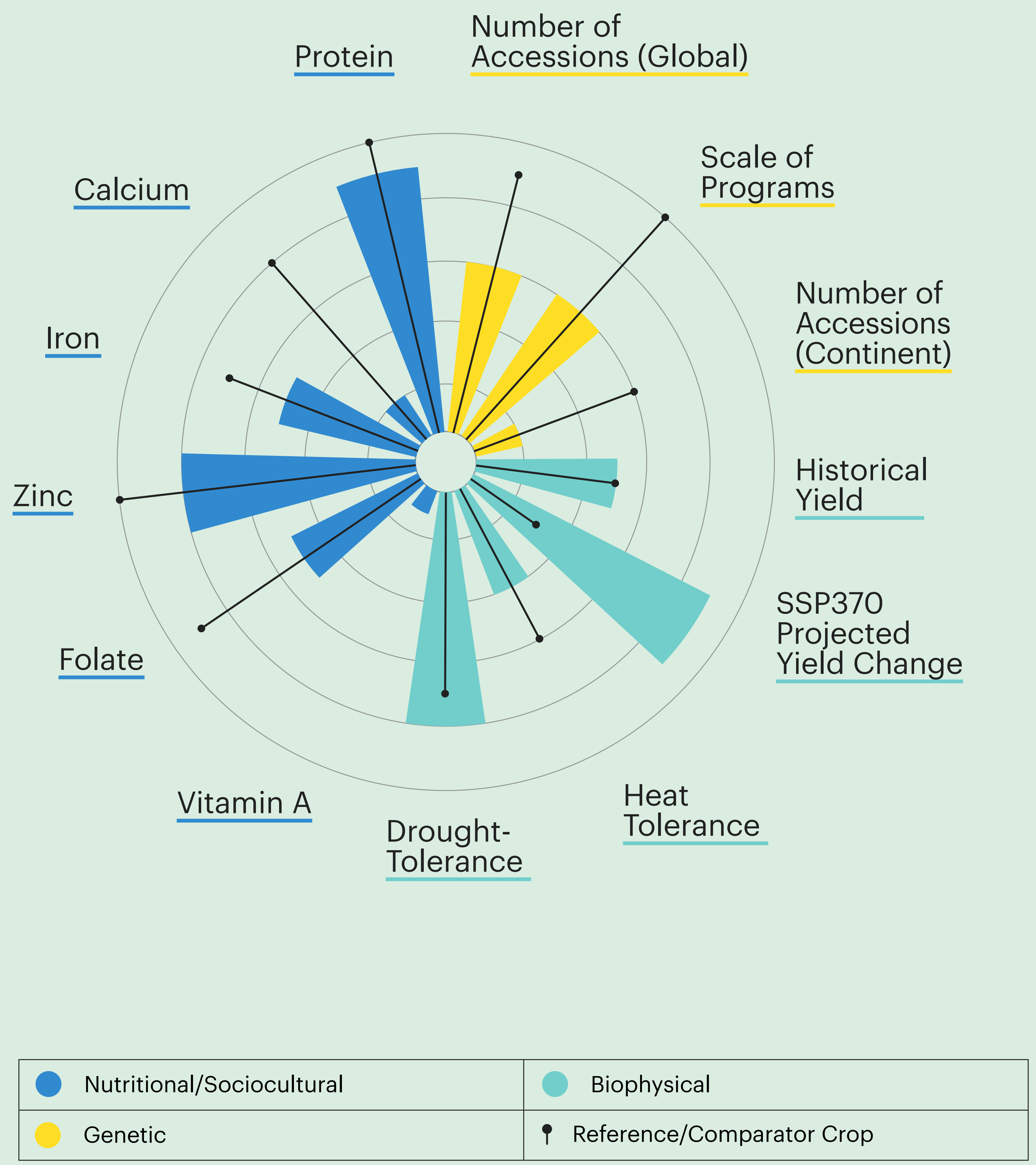
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Grass Pea

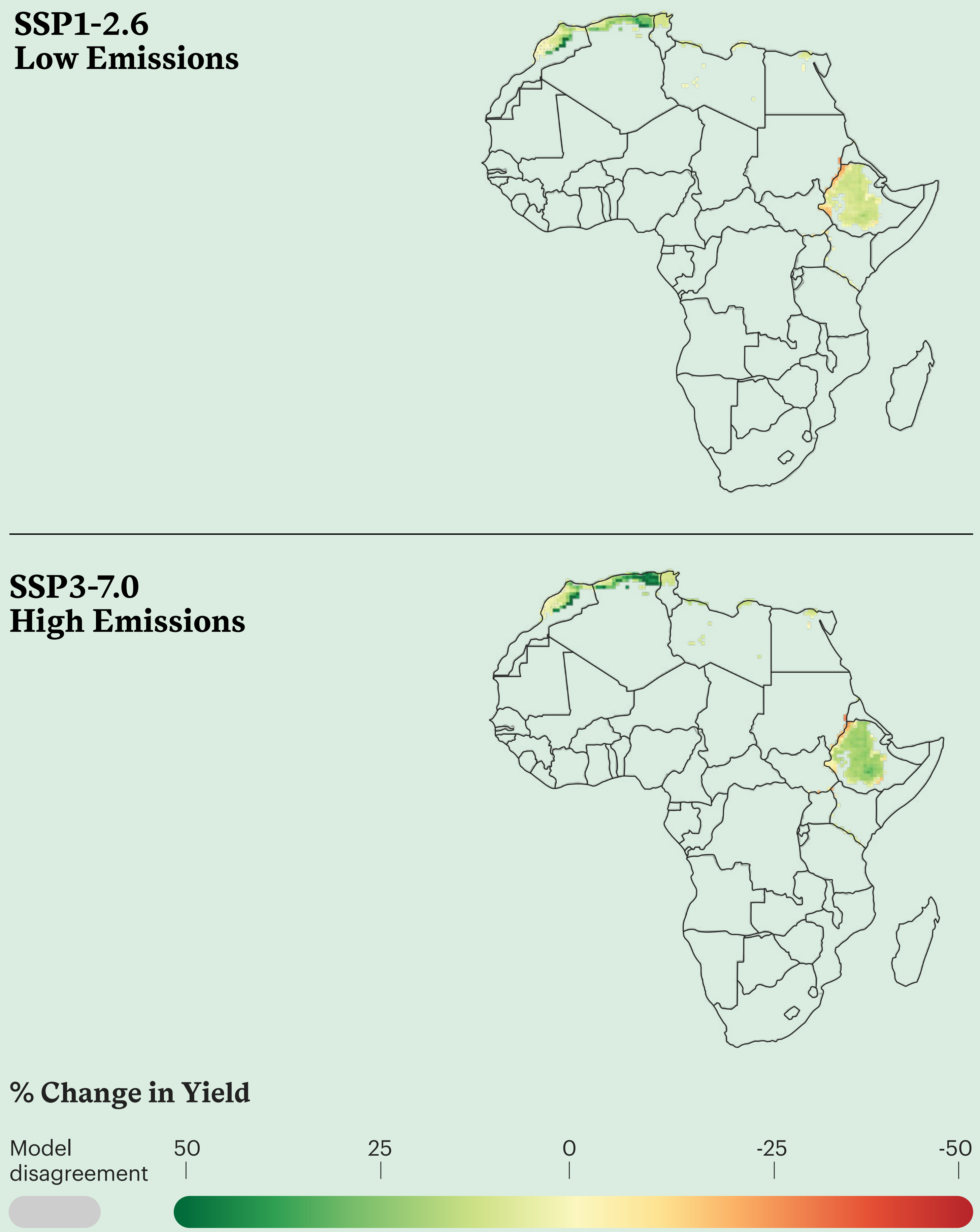
## Climate Change Assessment

Compared to soybean, grass pea is not as rich in micronutrients such as calcium and iron. Nevertheless it has substantial levels of protein and zinc. Grass pea is a highly underdeveloped crop at both the global and continent level. It has relatively few accessions available in Africa. Grass pea is very drought tolerant and is expected to see an increase in project yield under both climate change conditions modeled. This is apparent mostly in Northern and Eastern Africa.

## Adaptation Indicators



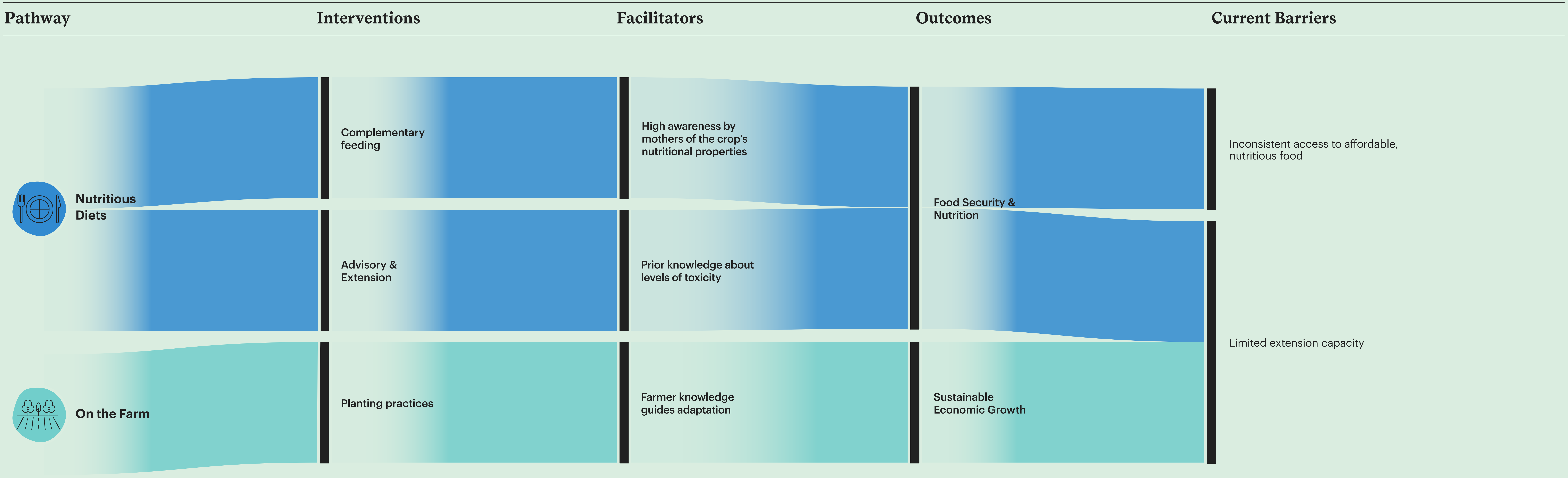

## Yield Projections under Climate Change



# **Grass Pea** Intervention Pathways

Grass pea is an important legume for several countries in Africa, including Ethiopia. Interventions include advisory and extension services, especially around nutrition and food safety awareness. Grass pea can contribute to a form of paralysis if consumed in large quantities, especially in children. Other interventions focus primarily on guidance on best practices to support crop management practices.

Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental



# Pigeon Pea *Cajanus cajan*

"Huge potential to alleviate the impact of climate change... high market demand...[high] availability of genetic and genomic resources...need for improvement of traits to meet market demand"

*Expert plant breeder*

## Adaptation Indicators

Pigeon pea is a significant legume crop cultivated extensively across various regions of Africa, including countries like Kenya, Malawi, Tanzania, Uganda, and Mozambique. This crop is predominantly grown by smallholder farmers and is valued for its adaptability to a wide range of environmental conditions and its ability to thrive in less fertile soils, making it a reliable option for farmers. Pigeon pea's drought-resistant characteristics and deep rooting system enable it to access water from deeper soil layers, enhancing its suitability in semi-arid and arid regions where water scarcity is a common challenge.

Pigeon pea has a relatively long growth cycle, which can vary from short-duration varieties maturing in about 4 - 11 months. This variation allows for flexibility in cropping systems and ensures a prolonged harvest period, which can be crucial for sustained food supply in smallholder farming communities. Pigeon pea also plays a role in improving soil fertility through nitrogen fixation. However, the crop is susceptible to various pests and diseases, necessitating effective management strategies for optimal yields.

Pigeon pea boasts a large market size and consumer preference locally and globally, and has an expanding seed development program, especially in eastern and southern Africa. Its cultivation supports the livelihoods of numerous smallholder farmers and contributes to sustainable agricultural practices in the region.

## Key Features

- Climate-resilient yield potential
- Drought-tolerant
- Disease-resistant
- Pest-resistant
- Heat-tolerant
- Relative high concentration of folate
- Relative high concentration of protein
- High lean season value
- Water use efficiency (WUE)
- Contributes to soil health
- Nutrient use efficiency
- High plant genetic resources in Africa
- Genomic sequencing completed or underway

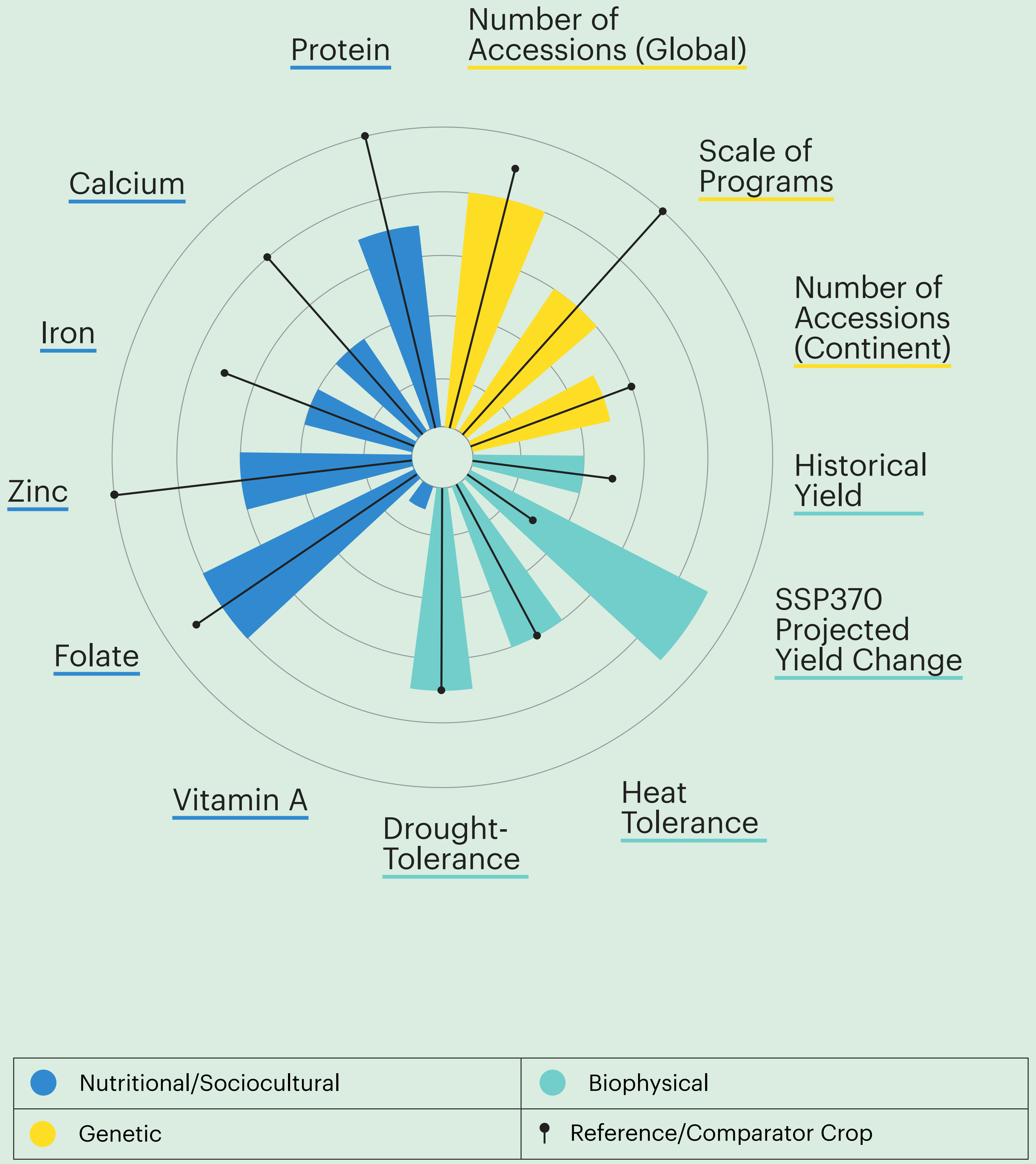
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Pigeon Pea

## Climate Change Assessment

Pigeon pea is not as nutritionally dense as soybean, but still possesses substantial protein, zinc, and folate levels. Pigeon pea has a large number of global accessions but a moderate level of continent-held accessions. The scale of genetic programs in Africa is also more regional. Pigeon pea is similar in drought- and heat-tolerance compared to soybean, but is projected to see general increases in relative yield change under climate change. We see an overall average increase in yield projections in both emissions scenarios.

## Adaptation Indicators




## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**

**SSP3-7.0**
**High Emissions**

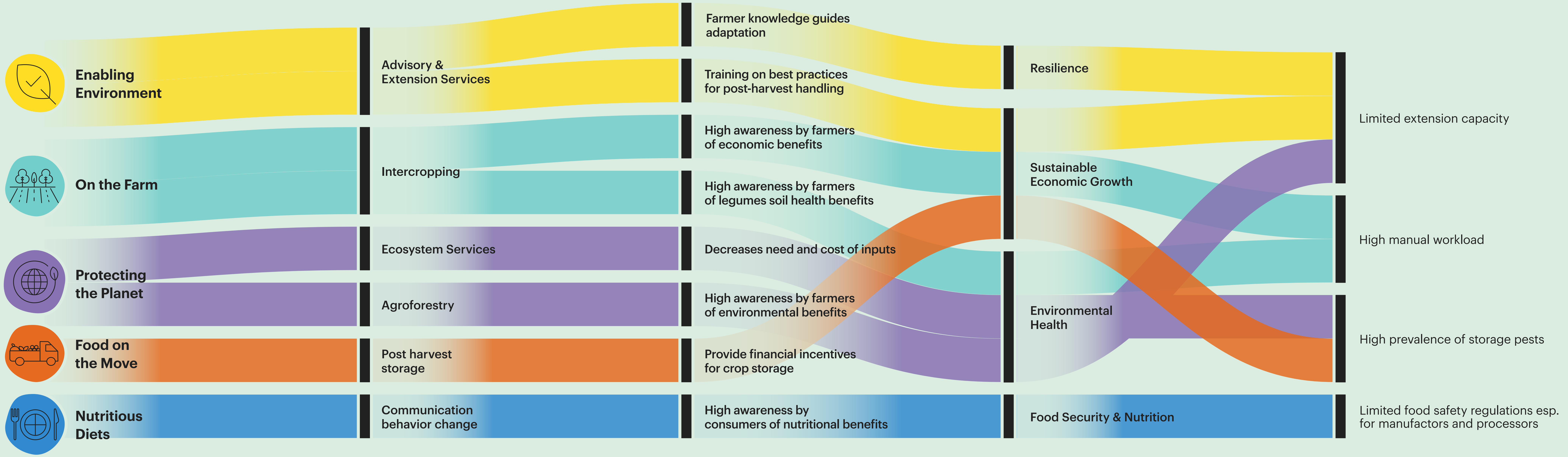
**% Change in Yield**

# **Pigeon Pea** Intervention Pathways

There is high-quality evidence on opportunities to improve pigeon pea. Interventions delivered through advisory and extension services include training on best practices for on-farm management and post-harvest processing to improve economic growth and food security. In addition, knowledge about the benefits of intercropping are highly promoted; however, some studies bring attention to increased labor that results from farmers investing in multiple cropping systems.

Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental

**Pathway** | **Interventions** | **Facilitators** | **Outcomes** | **Current Barriers**



# Bambara Groundnut
## *Vigna subterranea*

“It exhibits all three drought tolerance mechanisms—avoidance, escape, and tolerance. It can grow in contrasting environments. Excellent crop adapted to climate change and huge genetic variability exists, suggesting that the crop can be bred to improve any specific trait. Flowers are brittle making crosses difficult.”

*Expert plant breeder*

### Opportunity Crop Profile

Bambara groundnut is a legume cultivated extensively across Sub-Saharan Africa, with notable cultivation in countries like Nigeria, Cameroon, Ghana, Mali, and Burkina Faso. It is particularly valued in regions with challenging environmental conditions due to its hardiness and ability to grow in poor soil quality with low fertility. Bambara groundnut is drought-resistant, making it a reliable crop choice in semi-arid areas and regions prone to erratic rainfall patterns.

Smallholder farmers predominantly grow Bambara groundnut, often as part of subsistence farming systems. It is typically cultivated in intercropping systems alongside other staple crops, such as maize, sorghum, and cassava. This practice not only maximizes land use but also contributes to the diversification of diets and income sources. It is also rich in fiber and has a low glycemic index, making it beneficial for blood sugar management. Bambara groundnut can be boiled, roasted, or ground into flour for different culinary applications. The crop’s resilience, combined with its nutritional properties, positions Bambara groundnut as a high-potential component in efforts to enhance local food security and promote sustainable agriculture practices.

### Key Features

- High yielding under current climate
- Drought-tolerant
- Disease-resistant
- Pest-resistant
- Supports animal and livestock health
- High Value Chain Potential
- High lean season value
- Cultural significance
- Water use efficiency (WUE)
- Contributes to soil health
- Nutrient use efficiency
- Genomic sequencing completed or underway

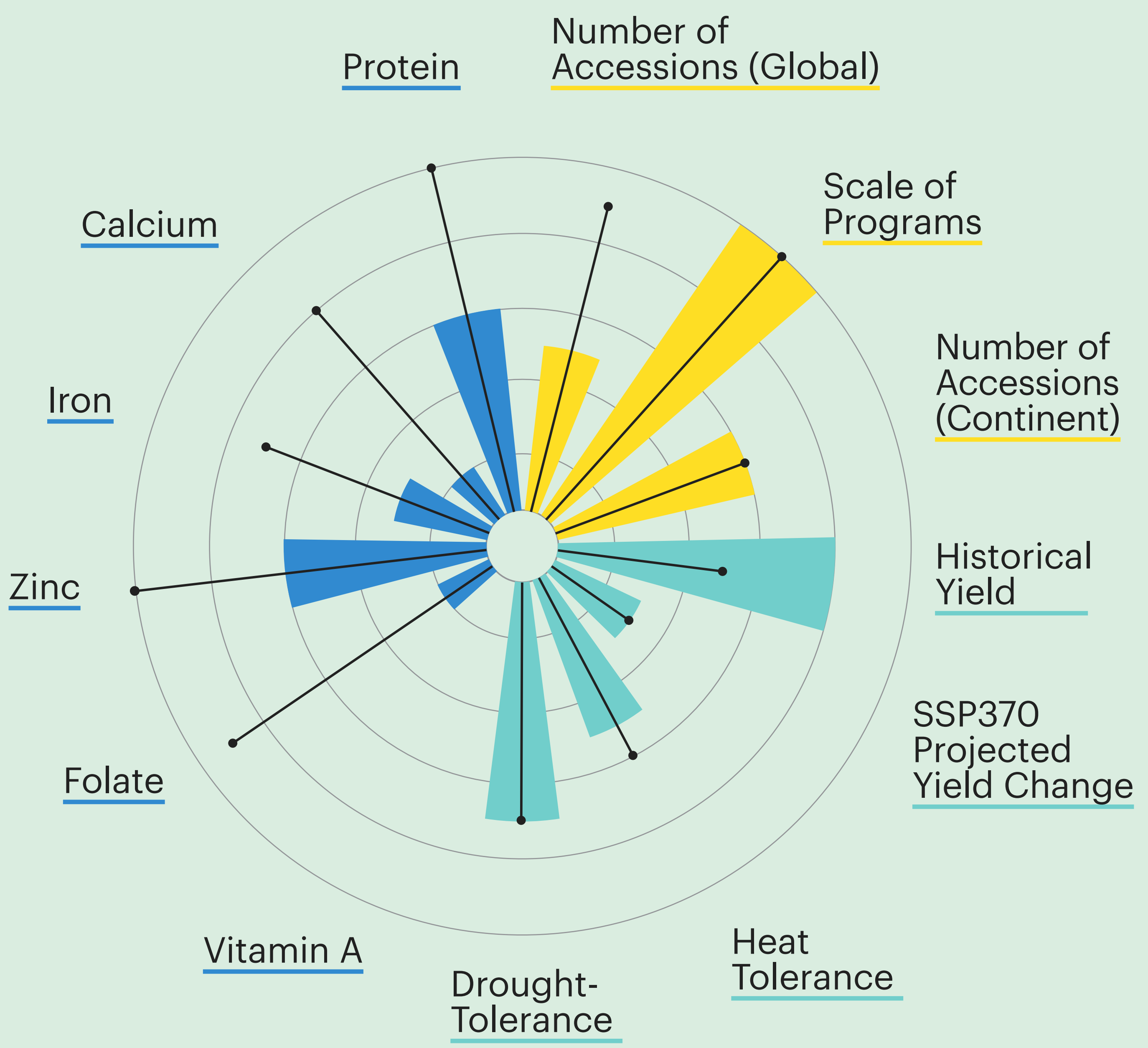
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Bambara Groundnut

## Climate Change Assessment

Bambara Groundnut has lower levels of iron, protein and zinc. Bambara groundnut has a comparable number of accessions to soybean at the continent level but is under-invested in globally. The scale of its current breeding programs are extensive. Bambara groundnut is similar in drought and heat tolerance to soybean and has varied yield change projections under climate change with its current genetics. It is poised to be impacted negatively in West Africa in both emission scenarios but to prove resilient in Central Africa.

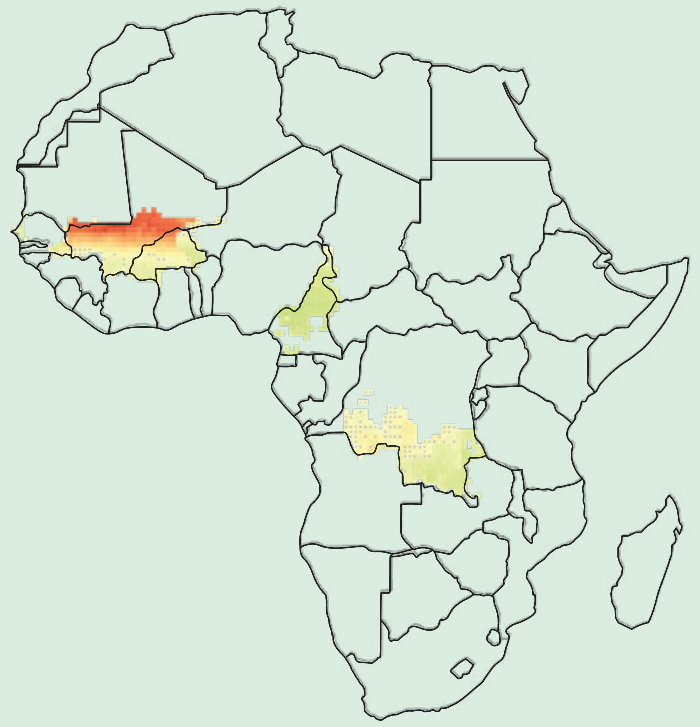
## Adaptation Indicators



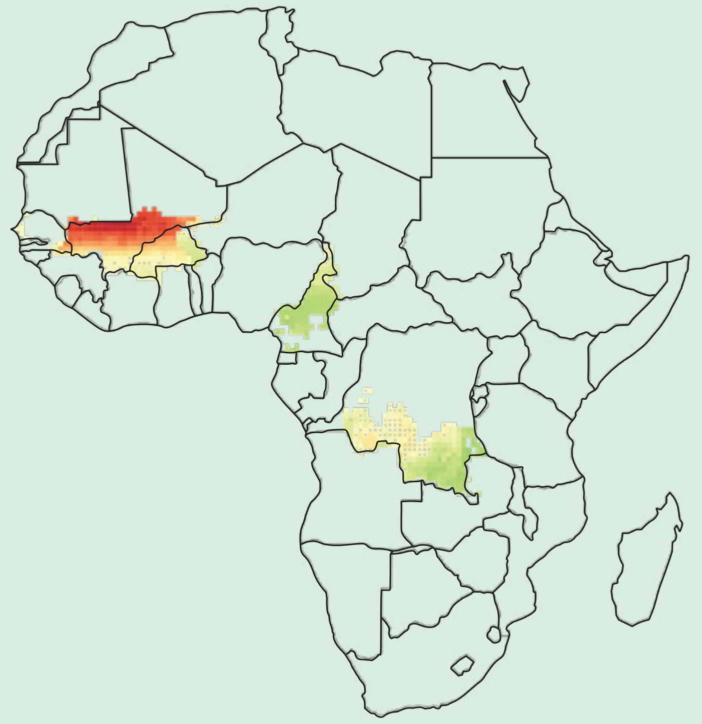

| | |
|---|---|
| Nutritional/Sociocultural | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**



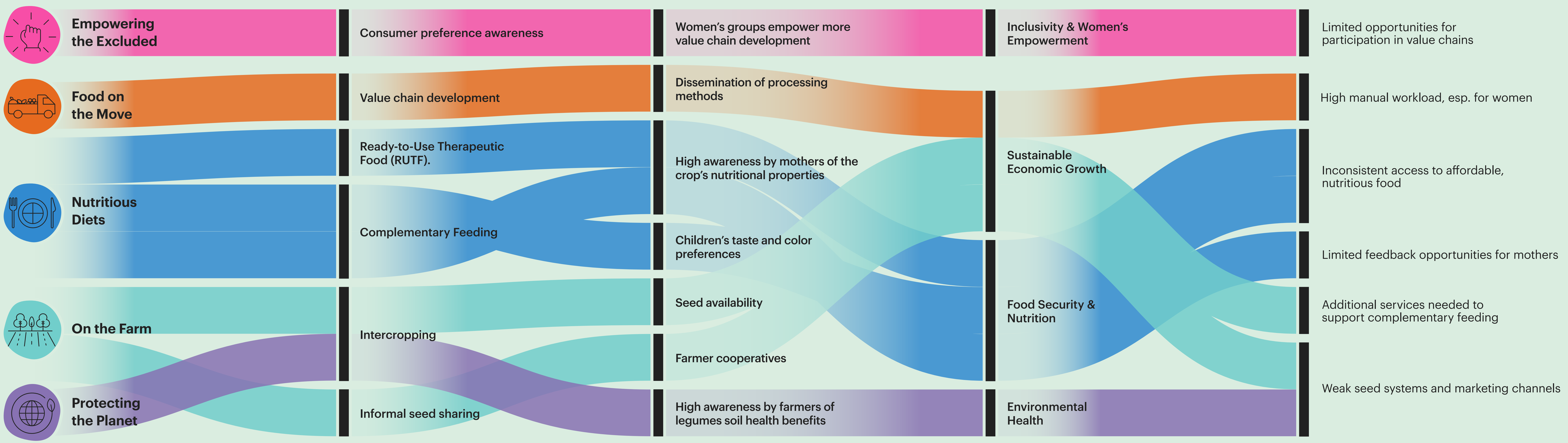
**% Change in Yield**

# **Bambara Groundnut** Intervention Pathways

The evidence for Bambara Groundnut highlights opportunities to improve crop management, healthy diets, and value chain development. Women play an important role in cultivating and developing the value chain for this crop. An important facilitator for women farmers to improve economic and women's empowerment is continued access to social networks, and advisory and extension services, through women's groups and organizations.

Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental

**Pathway** | **Interventions** | **Facilitators** | **Outcomes** | **Current Barriers**



# Lablab *Lablab purpureus*

## Opportunity Crop Profile

Lablab, also known as hyacinth bean or bonavist, is a leguminous crop cultivated in various parts of Africa, including countries such as Kenya, Tanzania, Uganda, and Ethiopia. This crop is valued for its versatility in different agricultural systems and environmental conditions, thriving well in tropical climates, and being adaptable to a range of soil types.

In agricultural practice, lablab is often grown by smallholder farmers as part of mixed cropping systems. It serves dual purposes, both as a food source and as a means of improving soil health. The crop is known for its ability to fix nitrogen, and enhance soil fertility, and is often used as a cover crop or intercropped with cereals like maize and sorghum. This practice not only improves soil quality but also offers protection against soil erosion. Lablab is relatively resilient to pests and diseases, although may require some management for optimal growth and yield.

The beans can be prepared in various ways, commonly used in stews, soups, and as a boiled vegetable. In addition to its nutritional value, lablab also holds cultural significance, where it is integrated into traditional dishes and culinary practices.

**“Genome under way. Crop with high potential in Africa and Asia”**

*Expert plant breeder*

## Key Features

- Drought-tolerant
- Disease-resistant
- Pest-resistant
- Relative high concentration of Iron
- Relative high concentration of protein
- High lean season value
- Genomic sequencing completed or underway
- Water use efficiency (WUE)
- Contributes to soil health

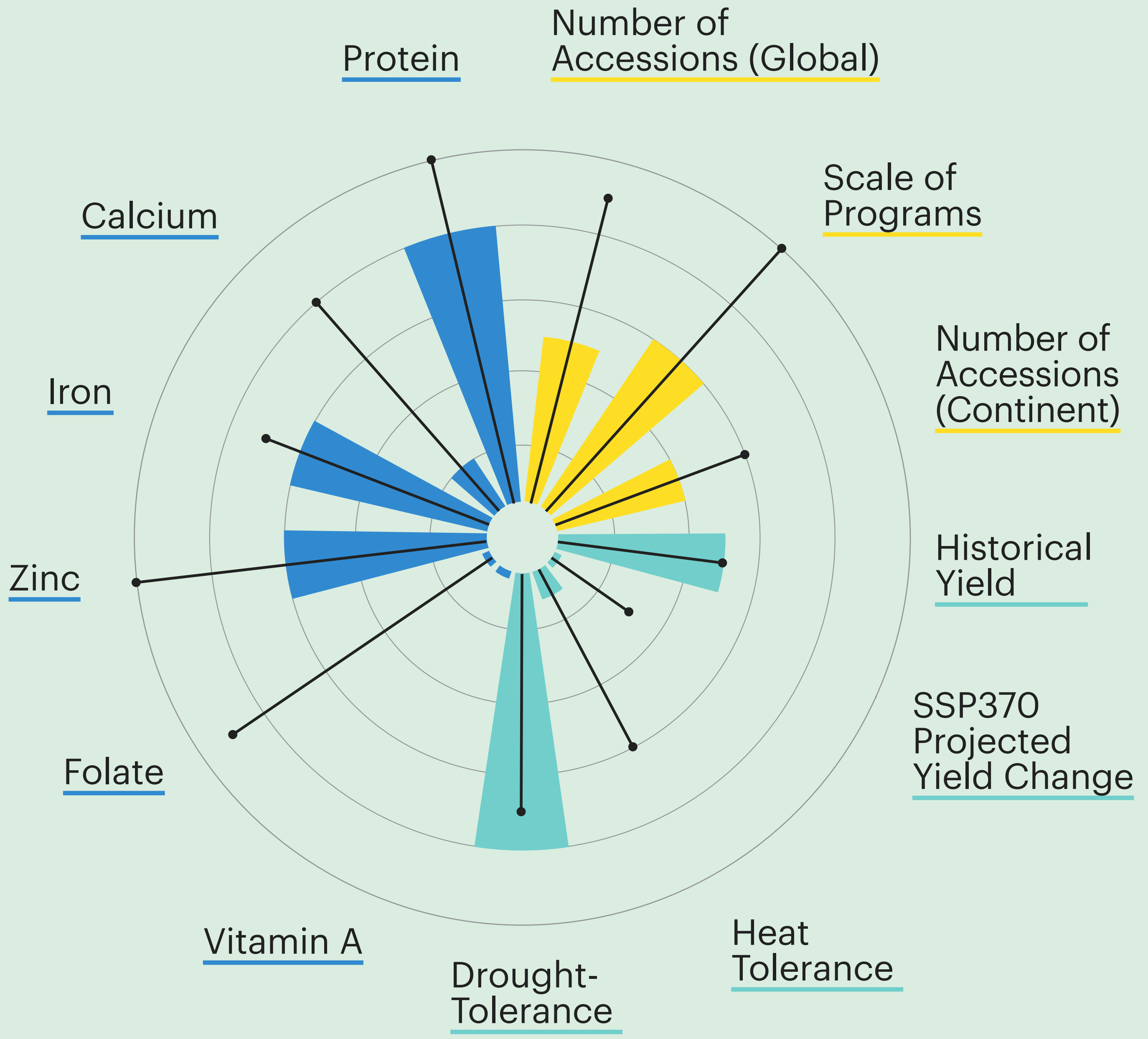
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Lablab

## Climate Change Assessment

Lablab has moderately high levels of micronutrients such as zinc and iron and relatively low amounts of calcium. It also has low amounts of folate and vitamin A. Lablab has modestly scaled breeding programs currently, with relatively few accessions held at the global and continental level. Lablab is very drought tolerant compared to soybean but has little heat tolerance. In addition, Lablab is projected to see an overall decrease in projected yield change under climate change. This decrease is substantially seen across the continent in West, East, Central, and Southern Africa in both SSP1-2.6 and SSP3-7.0 scenarios.

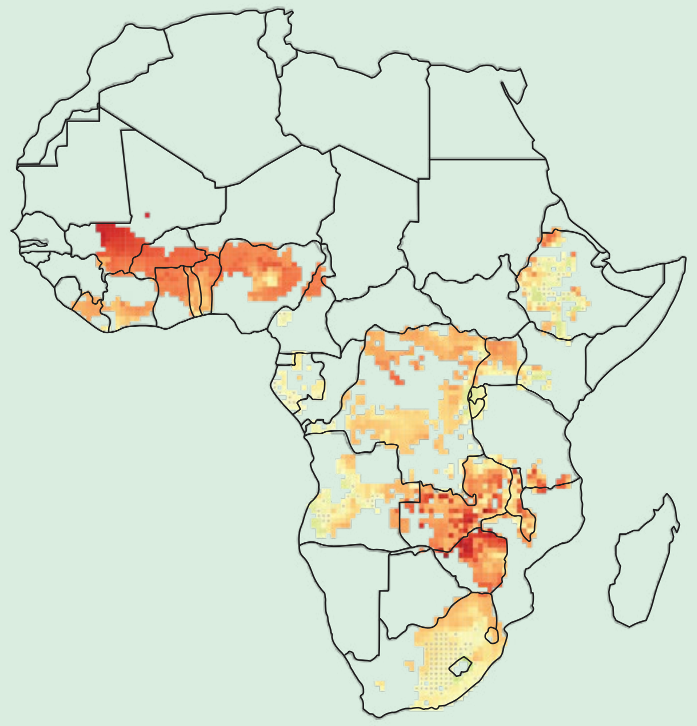
## Adaptation Indicators



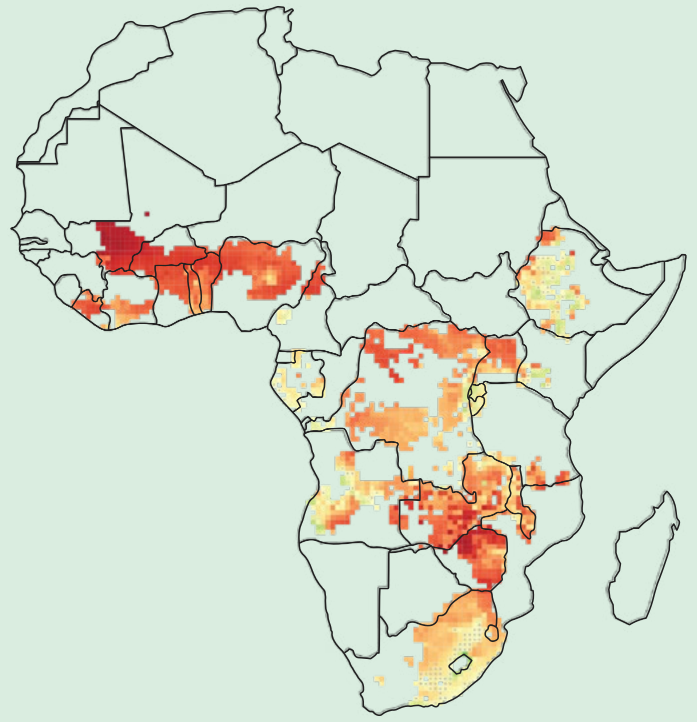

| | |
|---|---|
| Nutritional/Sociocultural | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**

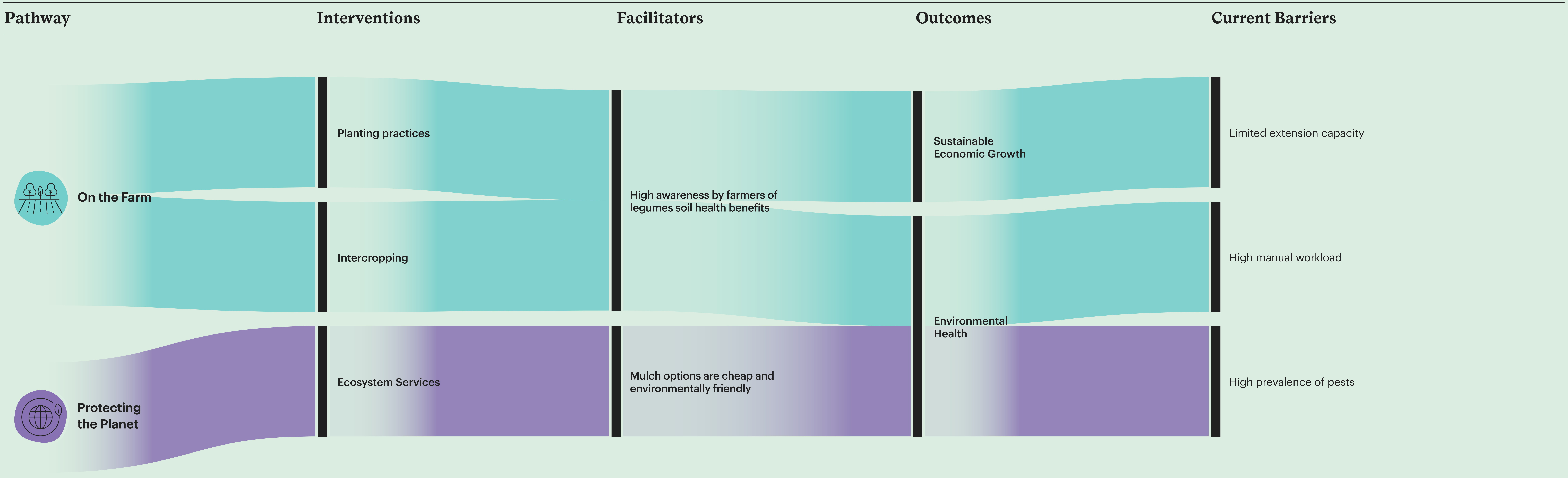


**% Change in Yield**

# **Lablab** Intervention Pathways

Evidence for lablab is limited, but the importance of intercropping is stressed across multiple studies. Intercropping with grains, but also with other legumes including pigeon pea, has important soil health benefits. These benefits also give way to a decreased need for costly inputs. Finally, the adoption of legumes (in this case lablab) is enhanced when farmers have an opportunity to learn about the impacts of climate change from other farmers who have experienced it firsthand.

| Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental |
|---|---|---|---|---|---|



# Mung Bean/Green Gram
*Vigna radiata*

## Opportunity Crop Profile

Mung bean, also known as green gram, is a leguminous crop with presence across various regions of Africa, including countries like Kenya, Uganda, and Ethiopia. Originally from South Asia, mung bean has adapted well to different climates, primarily due to its short growing cycle and adaptability to a range of conditions. Its ability to grow in semi-arid regions, as well as its minimal water requirement, makes it particularly valuable in areas facing water scarcity and fluctuating climatic conditions.

Mung bean has a relatively fast growth cycle, typically maturing in 60-90 days, allowing for quick turnover and flexibility in crop rotation systems. This feature is especially beneficial for smallholder farmers looking to maximize their yield within limited time frames. Mung bean also contributes positively to soil health through nitrogen fixation, a characteristic trait of legumes, which can improve soil fertility and reduce the need for synthetic fertilizers. However, challenges such as susceptibility to pests and diseases, particularly in more humid regions, necessitate effective crop management strategies. Mung bean is a significant source of protein, dietary fiber, and essential nutrients like potassium, magnesium, and folate.

**"Current breeding mainly focused on Asia. Huge potential in Africa, as well as potential for significant South-South partnership"**

*Expert plant breeder*

## Key Features

- B-9 — Relative high concentration of folate
- Relative high concentration of protein
- Fe — Relative high concentration of Iron
- Zn — Relative high concentration of Zinc
- High plant genetic resources in Africa
- Genomic sequencing completed or underway
- Disease-resistant
- High consumer acceptance
- High Value Chain Potential
- Water use efficiency (WUE)
- Nutrient use efficiency

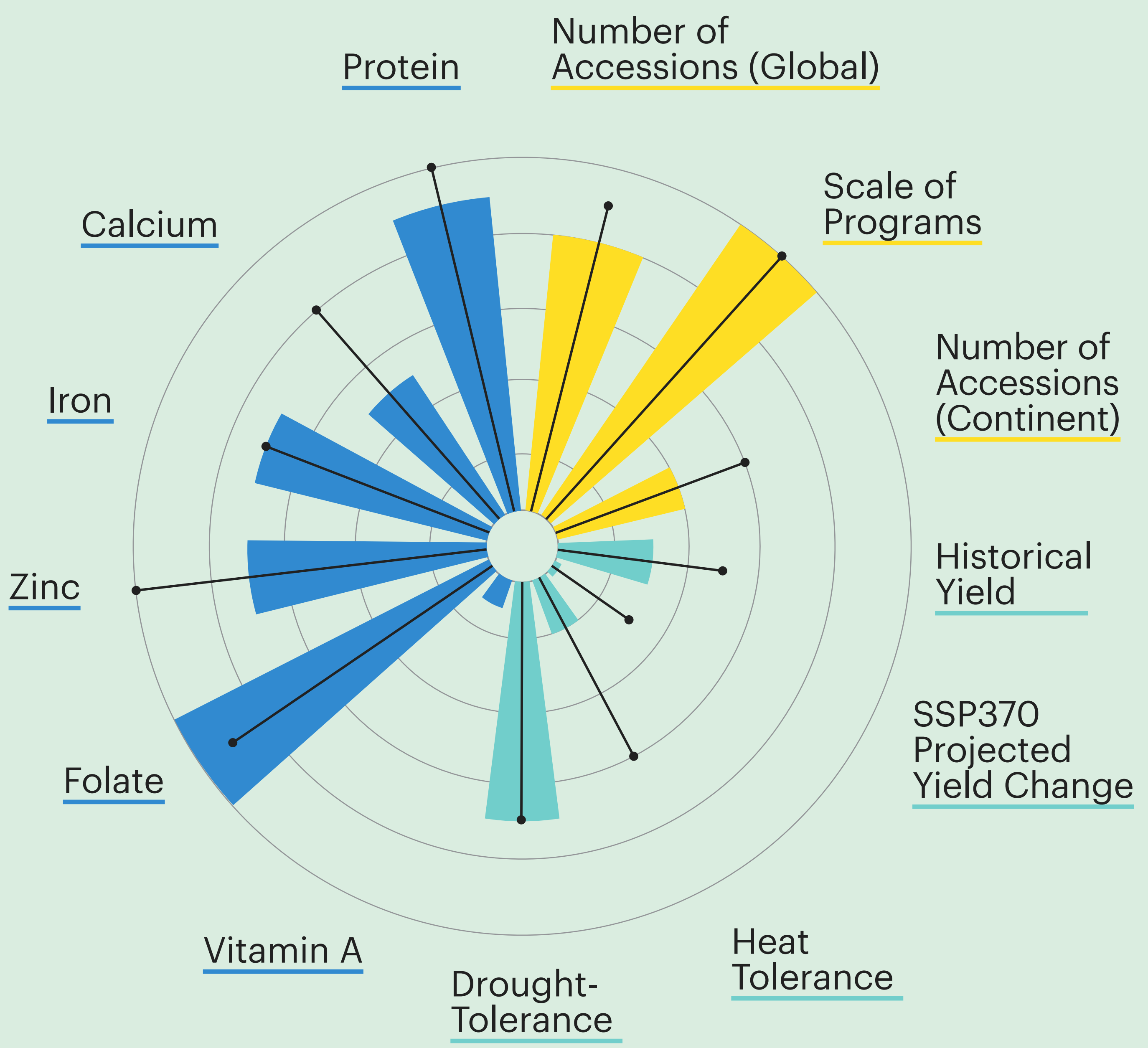
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Mung Bean/ Green Gram

## Climate Change Assessment

Mung bean has protein, folate and iron levels comparable to soybean but lower levels for calcium and zinc. Mung bean has extensive global breeding programs, but relatively few accessions available in Africa. Mung bean is similarly drought tolerant compared to soybean but is less heat tolerant. Mung bean is projected to see a continued decrease in projected yield change under climate change. This decrease is substantially seen in West Africa near the Sahel and moderately in Central Africa under both SSP1-2.6 and SSP3-7.0 scenarios. It is important to note that spatially explicit data on mung bean production were limited, and that it is possible that modeling mung bean in other geographies would lead to more climate-resilient projections overall.

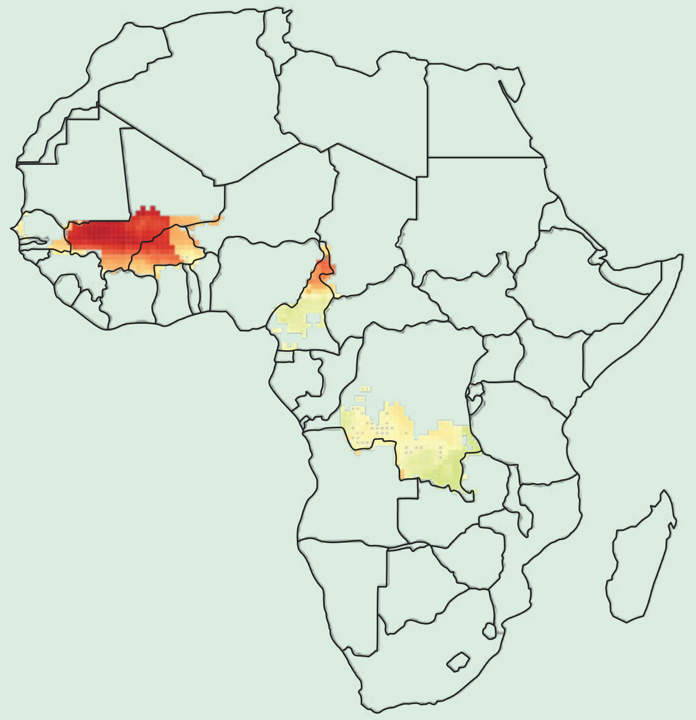
## Adaptation Indicators



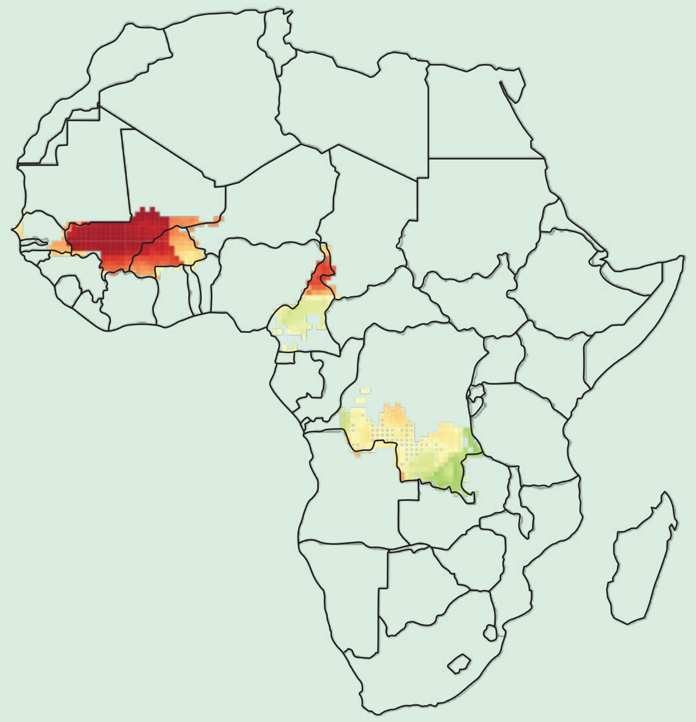

| | |
|---|---|
| Nutritional/Sociocultural | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



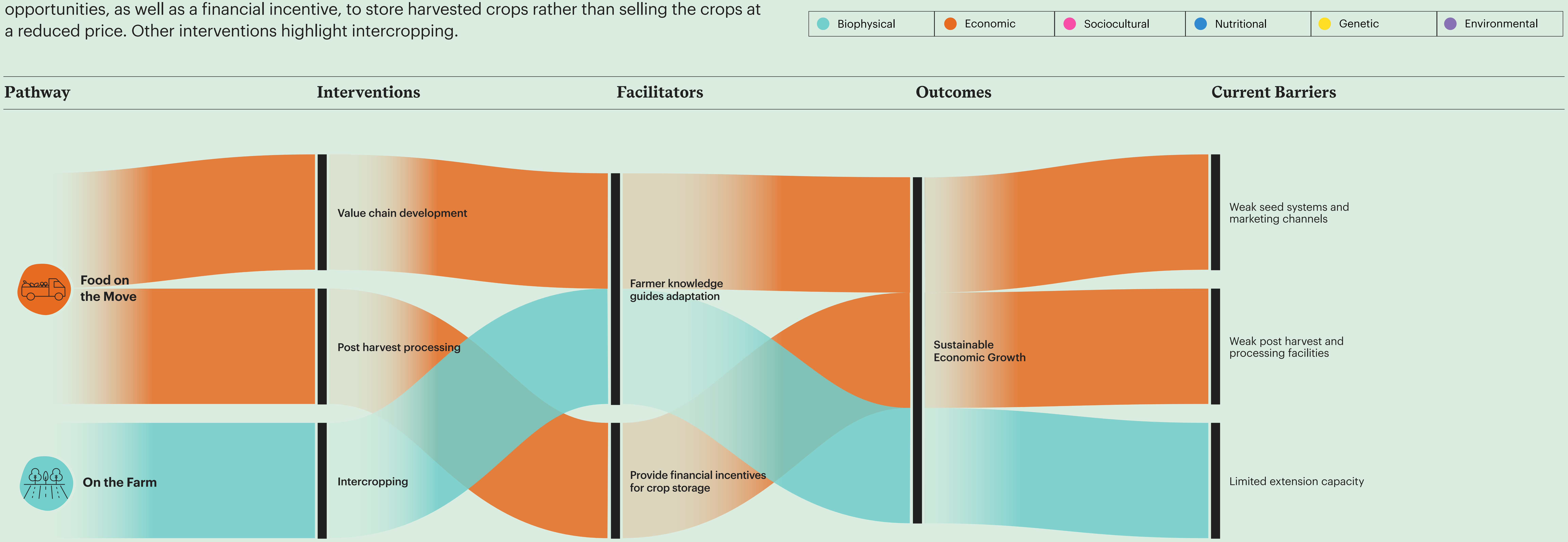
**SSP3-7.0**
**High Emissions**



**% Change in Yield**

# **Mung Bean/Green Gram** Intervention Pathways

Mung bean is well-known for providing nutritional benefits and a range of on-farm benefits as part of multi-cropping systems. Despite this, evidence for mung bean is limited. One study focused on ensuring competitive prices for mung bean at the market by providing farmers with storage opportunities, as well as a financial incentive, to store harvested crops rather than selling the crops at a reduced price. Other interventions highlight intercropping.

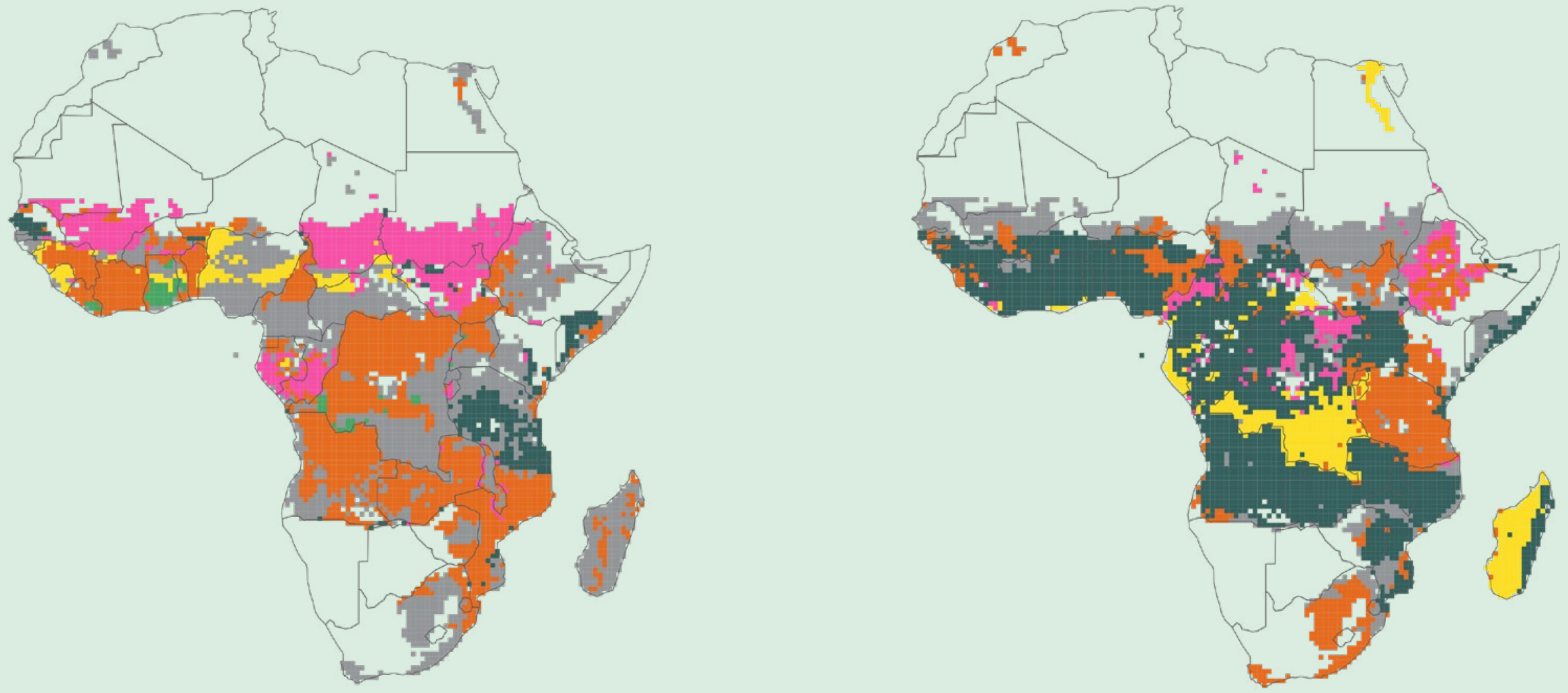



## Summary of Climate-Crop Modeling Results

This figure displays the combined yield change projections for all the roots and tubers that AgMIP has modeled to date. Yams are expected to decrease in productivity in many areas across Eastern Africa, and sweet potato is vulnerable in many areas in Central, Western and Southern Africa. On the other hand, cassava is poised to perform relatively well across the continent in a high-emissions scenario, with taro proving to be a resilient option in central Africa, and sweet potato a potentially climate-resilient option in parts of East Africa as well.

**Largest Yield Decrease**
SSP3-7.0 – High Emissions

**Largest Yield Increase**
SSP3-7.0 – High Emissions



**Legumes**

| | | | |
|---|---|---|---|
| None | Cassava | Cocoyam | Taro |
| Sweet potato | Yams | | |

# Cocoyam
*Xanthosoma sagittifolium*

**“Production is decreasing in many areas in Africa owing to research neglect (no breeding) and pressures on the relevant agroecologies. However, the crop has played important roles in nutrition (cormels and the leaves) and in stabilizing the root and tuber-based farming systems in the humid forest areas of West and Central Africa”**

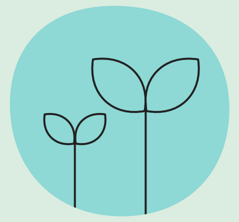
*Expert plant breeder*

## Opportunity Crop Profile

Cocoyam, also known as elephant ear or taro, is a tuber crop widely cultivated in various parts of Africa, including Nigeria, Ghana, Cameroon, and Uganda. It thrives in tropical climates, preferring humid conditions and fertile, well-drained soils. It thrives in humid climates and requires a consistent supply of moisture for optimal growth, making it particularly suited to regions with high rainfall. Cocoyam plants are known for their tolerance to shade, which allows them to be intercropped with taller crops or grown under tree canopies. This characteristic is advantageous in mixed farming systems, where land and light resources are efficiently utilized. In Nigeria, cocoyam cultivation contributes significantly to the agricultural sector, with an annual production of 5.49 million metric tonnes. This accounts for 45.9% of the world’s cocoyam production and 72.2% of the total output in West Africa.

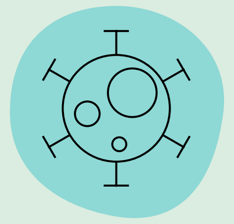
Cocoyam is primarily grown by smallholder farmers. The tubers and leaves of cocoyam are edible. Cocoyam is often used in stews, soups, and as a boiled or fried vegetable. Cocoyam, however, faces challenges such as susceptibility to pests and diseases like root rot and leaf blight. The crop’s adaptability to the local environment, combined with its cultural and nutritional importance, makes cocoyam a key component of food security and agricultural sustainability in the region.

## Key Features

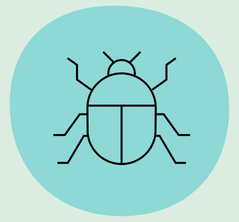


High yielding under current climate

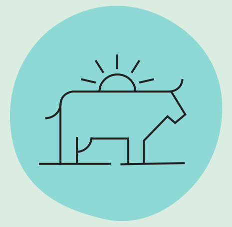
Drought-tolerant



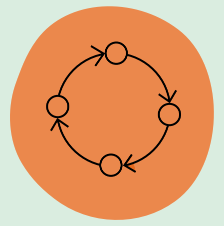
Disease-resistant



Pest-resistant



Supports animal and livestock health



High Value Chain Potential

Genomic sequencing completed or underway

High lean season value

| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Cocoyam
*Xanthosoma sagittifolium*

**“Production is decreasing in many areas in Africa owing to research neglect (no breeding) and pressures on the relevant agroecologies. However, the crop has played important roles in nutrition (cormels and the leaves) and in stabilizing the root and tuber-based farming systems in the humid forest areas of West and Central Africa”**

*Expert plant breeder*

## Opportunity Crop Profile

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Cocoyam is primarily grown by smallholder farmers. The tubers and leaves of cocoyam are edible. Cocoyam is often used in stews, soups, and as a boiled or fried vegetable. Cocoyam, however, faces challenges such as susceptibility to pests and diseases like root rot and leaf blight. The crop’s adaptability to the local environment, combined with its cultural and nutritional importance, makes cocoyam a key component of food security and agricultural sustainability in the region.

### Key Features

- High yielding under current climate
- Drought-tolerant
- Disease-resistant
- Pest-resistant
- Supports animal and livestock health
- High Value Chain Potential
- Genomic sequencing completed or underway
- High lean season value

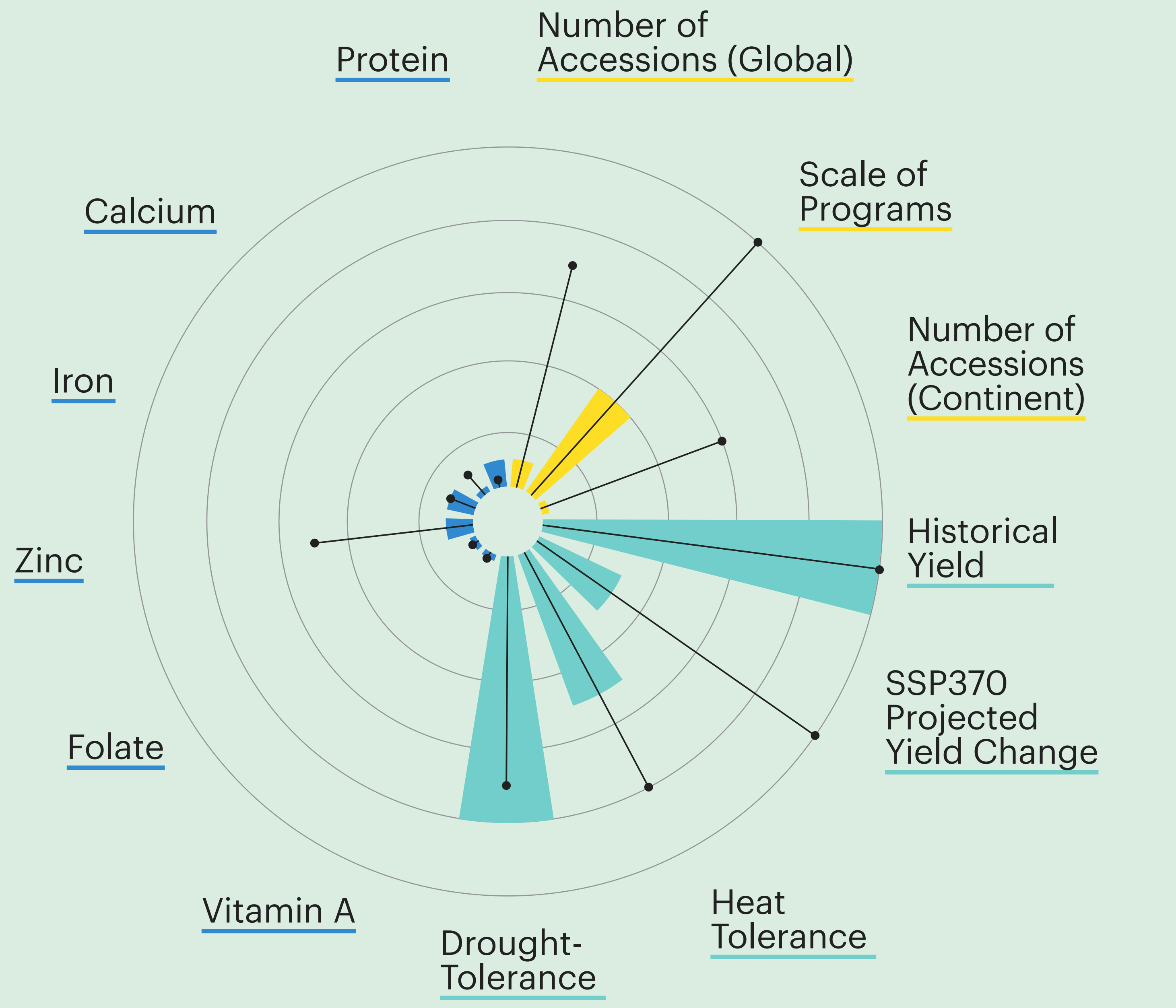
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Cocoyam

## Climate Change Assessment

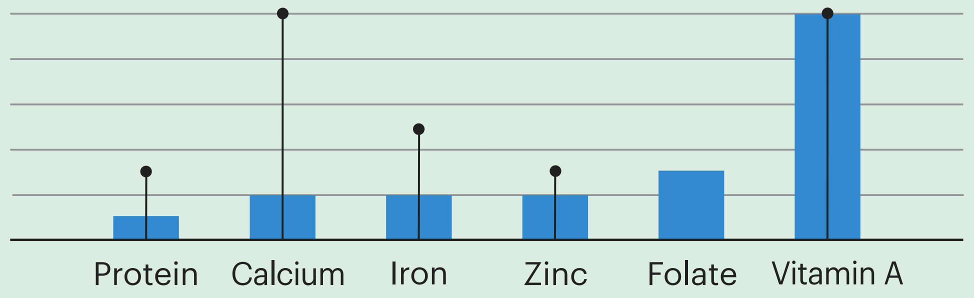
Cocoyam tubers have lower levels of micronutrients compared to other opportunity crops but are comparable to cassava (and other root crops). Cocoyam leaves showed higher micronutrient content than tubers, especially in vitamin A, but are still low compared to cassava leaves. Cocoyam is highly underinvested in, with small scale breeding programs and very few recorded accessions globally and continent-wide. Cocoyam is highly drought-tolerant and moderately heat-tolerant. Under both low and high emissions scenarios, there is a projected decrease in yield in West Africa and an increase in Central Africa. Interestingly, under SSP3-7.0, this decrease and increase in regional yields is stronger in both directions as compared to SSP1-2.6.

## Adaptation Indicators




### Cocoyam Leaf Nutrition

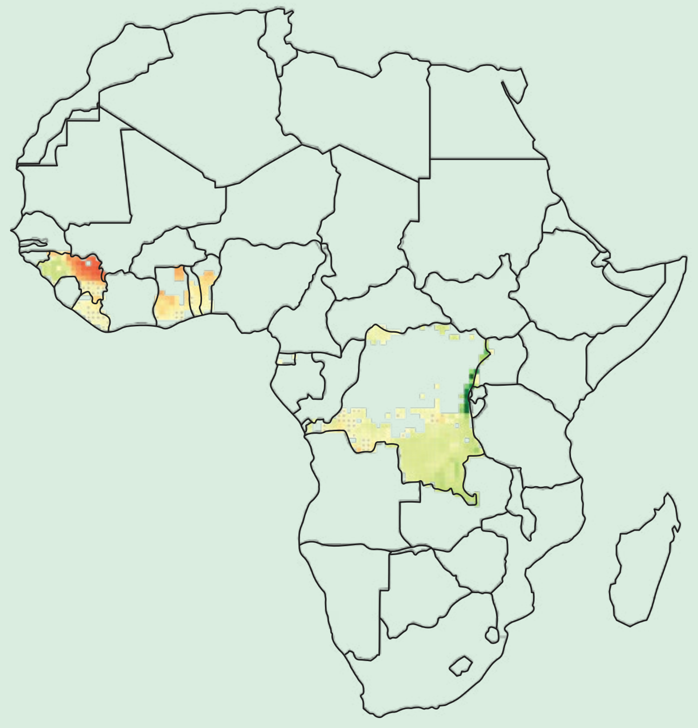
Reference/Comparator Crop: Cassava Leaves



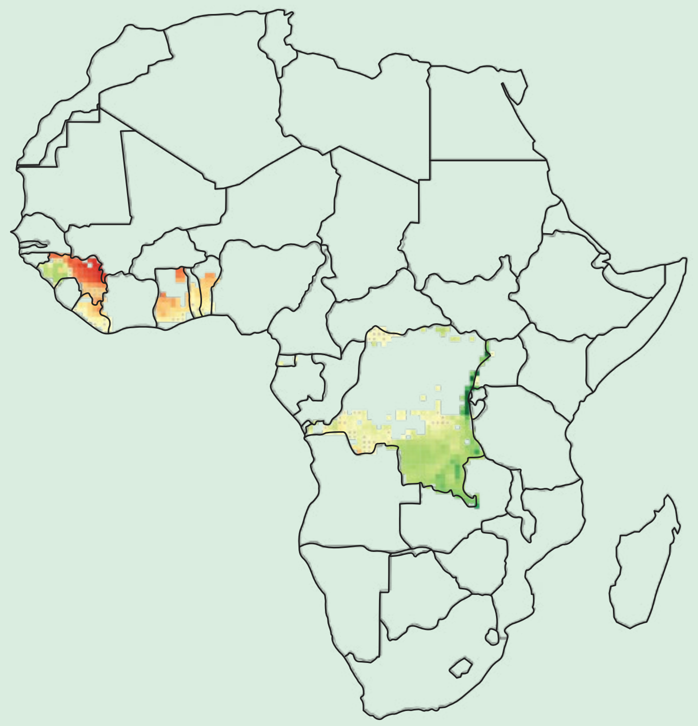

| | |
|---|---|
| Nutritional | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**



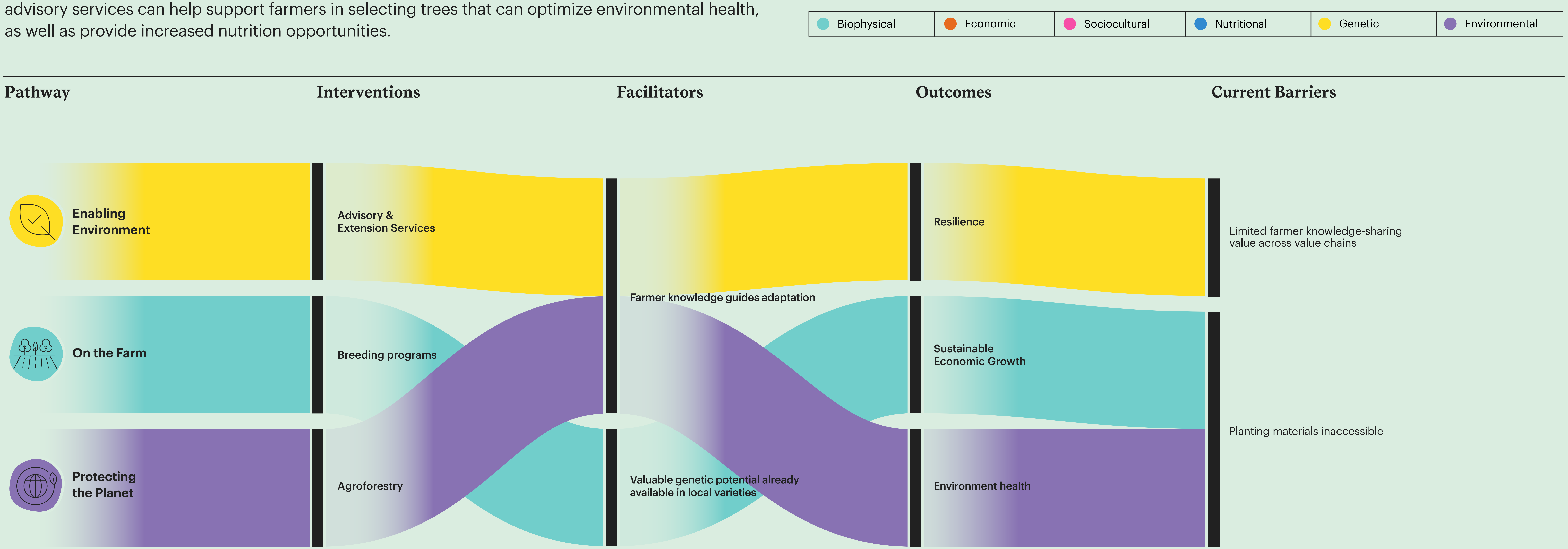
**% Change in Yield**

Model disagreement

50 | 25 | 0 | -25 | -50

# **Cocoyam** Intervention Pathways

While there is limited evidence about effective interventions for cocoyam, agroforestry emerges as one important opportunity. Currently, greater uptake of agroforestry as part of a multi-cropping system is limited in some contexts by access to planting materials. In addition, farmers often incorporate trees into the landscape based on their ease of propagation. Increased extension and advisory services can help support farmers in selecting trees that can optimize environmental health, as well as provide increased nutrition opportunities.



# Taro *Colocasia esculenta*

“Breeding is possible and important to address disease pressures and select for quality attributes suited to particular regions.”

*Expert plant breeder*

## Opportunity Crop Profile

Taro is a significant root crop cultivated in various African countries, including Nigeria, Ethiopia, Ghana, and Cameroon (accounting for 67% of the total taro production in Africa). Taro is known for its adaptability to a range of environmental conditions, thriving in both hot, humid areas with high rainfall typical of the tropical sub-Saharan region and in drier regions along streams, as found in Egypt, Algeria, and Libya. This versatility allows it to be cultivated under diverse conditions across Africa.

Taro can grow at altitudes ranging from 60 to 1850 meters above sea level, accommodating both tropical and temperate zones. Taro is known for its large, starchy corms, which are the primary edible part of the plant. Taro requires careful water management, as the plant needs a consistent and ample supply of moisture throughout its growth cycle.

Taro plants are generally tolerant of a range of soil types, provided the soil is fertile and well-drained. Its cultivation and distribution extend from southern to northern Africa, signifying its importance in the local agricultural systems and traditions. Taro’s ability to thrive under various soil conditions makes it a reliable food source in regions with fluctuating environmental conditions.

Taro corms can be prepared in various ways, including boiling, baking, and frying. The crop’s adaptability to wet conditions and its contribution to dietary needs make it an important component of agricultural systems in regions where water resources are plentiful.

## Key Features

High yielding under current climate

Climate-resilient yield potential

Supports animal and livestock health

Pest-resistant

Genomic sequencing completed or underway

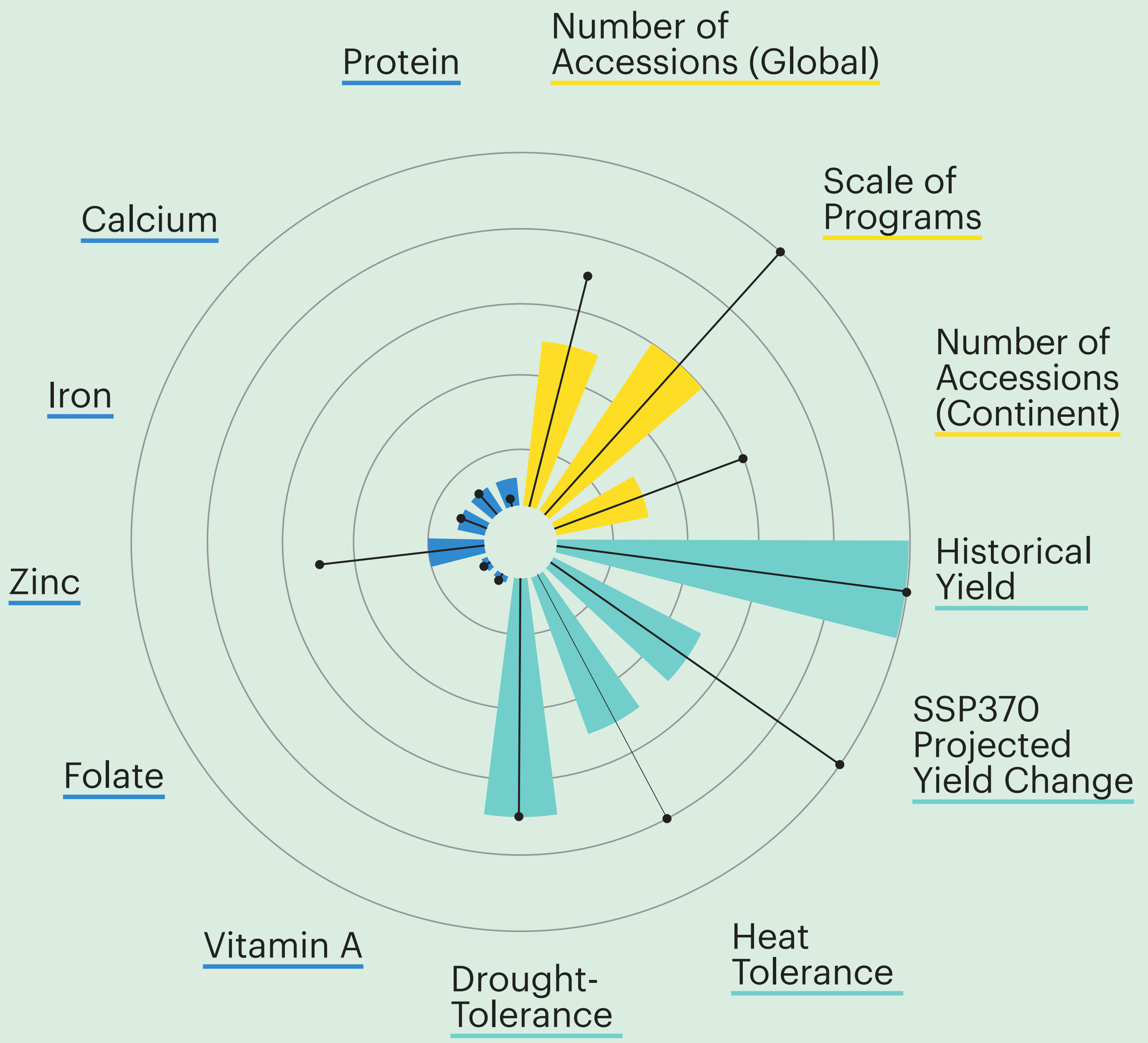
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

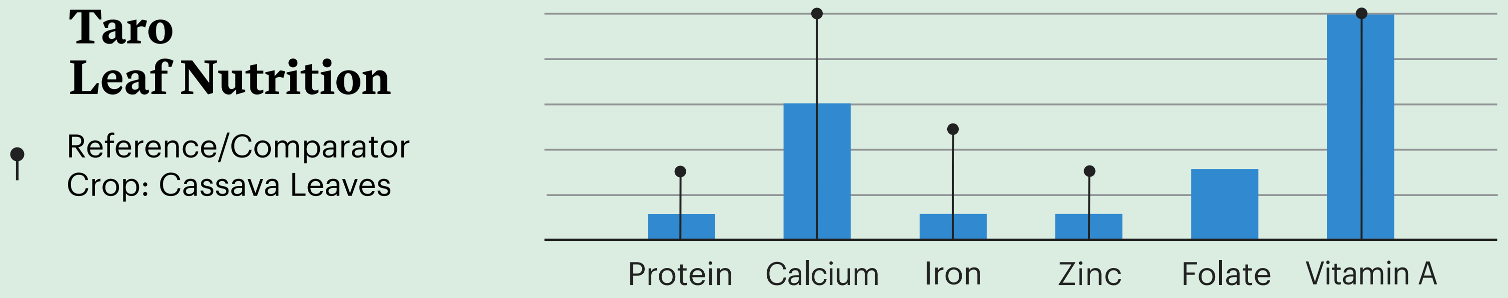
# Taro

## Climate Change Assessment

Taro tubers are comparable to cassava tubers in terms of nutrient content, except for zinc. Taro leaves are relatively high in calcium, folate and vitamin A. Taro has a moderate number of accessions held globally and breeding programs are largely regional. Its number of continent-wide accessions are somewhat low, especially compared to the reference crop cassava. Taro is drought-tolerant and moderately heat-tolerant but is expected to see a slight decrease in overall projected yield change across the continent. Under both low and high emissions scenarios, there is a projected decrease in yield in many parts of Western Africa and an increase across Central Africa.

## Adaptation Indicators

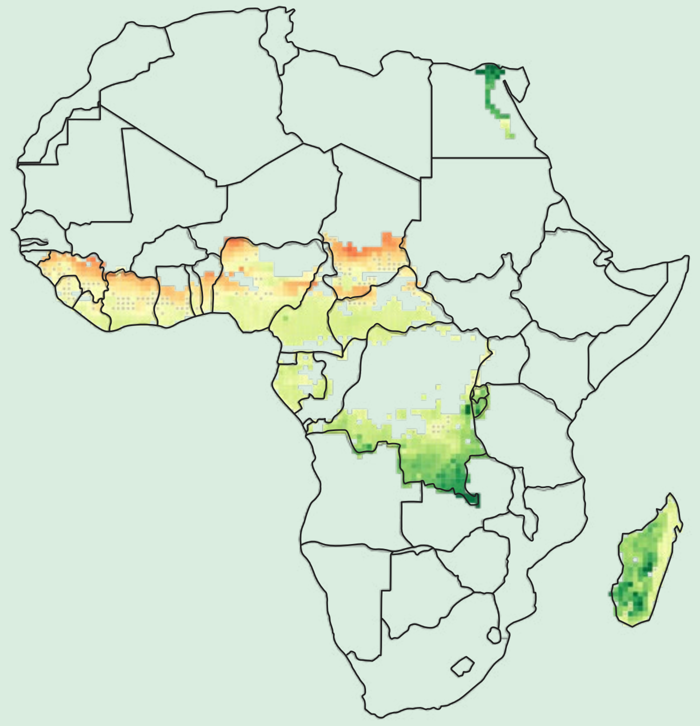


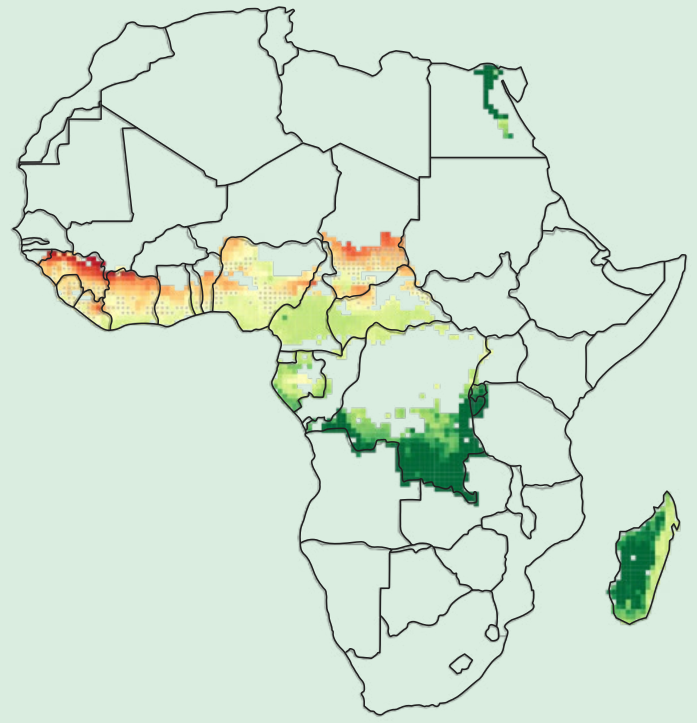

| | |
|---|---|
| Nutritional | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**



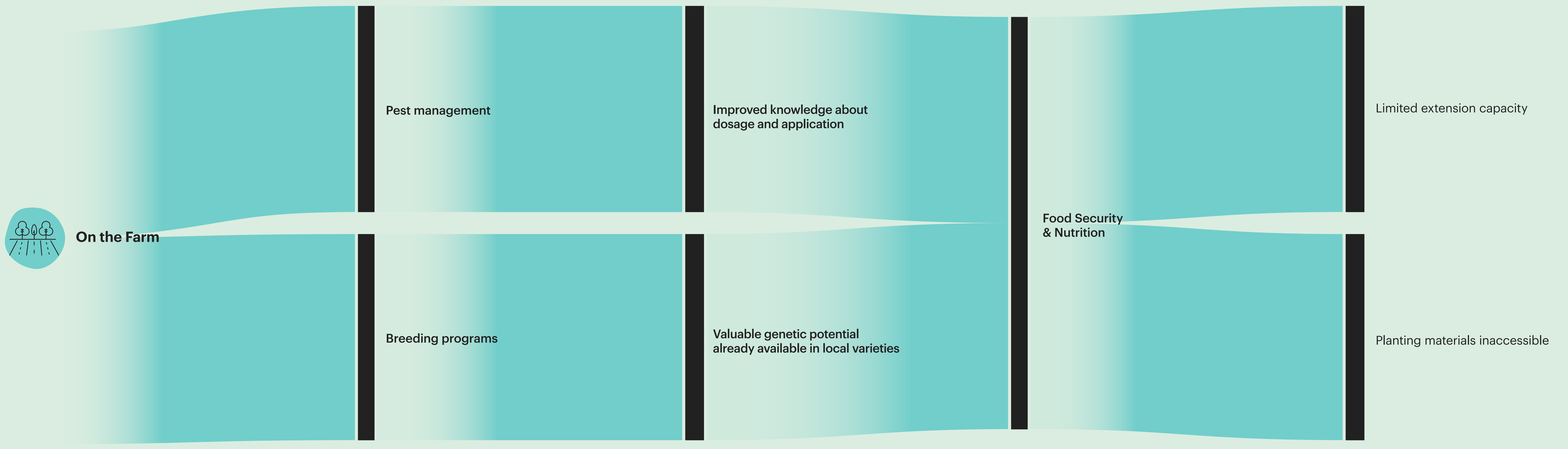
**% Change in Yield**

# **Taro** Intervention Pathways

While the evidence on taro in Africa is relatively limited (as compared to other regions, like Latin America), it remains an important crop for African food security. Some of the major challenges identified in the evidence assessment include pest management, as well as opportunities for improved varieties in the wake of climate change.

| Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental |
|---|---|---|---|---|---|

| Pathway | Interventions | Facilitators | Outcomes | Current Barriers |
|---|---|---|---|---|



# Yam *Dioscorea sp.*

## Opportunity Crop Profile

Yams, primarily grown in the "yam belt" of West Africa, are a vital food and cash crop, particularly in Nigeria, Ghana, Côte d'Ivoire, and Benin. Accounting for 98% of global yam supply, with Nigeria leading at 73%, yams significantly contribute to the region's food security and economy.

Yam cultivation is labor-intensive and follows a traditional pattern of shifting cultivation and bush-fallowing, requiring freshly cleared land. The crop places a substantial demand on soil nutrients, leading to soil degradation and scarcity of fertile land. Additionally, yams face limitations due to environmental stresses, pests, diseases, and the intensive use of herbicides like glyphosate for weed control. Yams thrive in warm weather conditions with adequate sunlight, humidity, and rainfall. They are primarily cultivated in the humid and subhumid lowlands, specifically in Deciduous Forest and Savannah agroecological zones. The suitable environmental conditions for yam production include well-distributed rainfall ranging from 900 to 2000 mm annually and temperatures between 20 and 35°C during the period of maximum growth. The long growing period of yams, ranging from 6 to 12 months, depends on factors like species, climatic conditions, planting material, genotype, and location.

Yam cultivation has almost tripled since 1990, driven by population growth and demand. Despite increased cultivation areas, yield fluctuations and recent declines highlight the need for addressing production constraints. High labor costs and declining youth participation in agriculture are among the key challenges.

"Breeding in progress and improved varieties released in Nigeria and Ghana. There is some opportunity, but flowering, crosses, high abortion rate, low seed and fruit set are major challenges. More basic research and investment to improve these traits are critical to improving breeding."

*Expert plant breeder*

### Key Features

- High yielding under current climate
- Climate-resilient yield potential
- Disease-resistant
- Heat-tolerant
- High consumer acceptance
- High Value Chain Potential
- Genomic sequencing completed or underway
- High plant genetic resources in Africa
- High lean season value

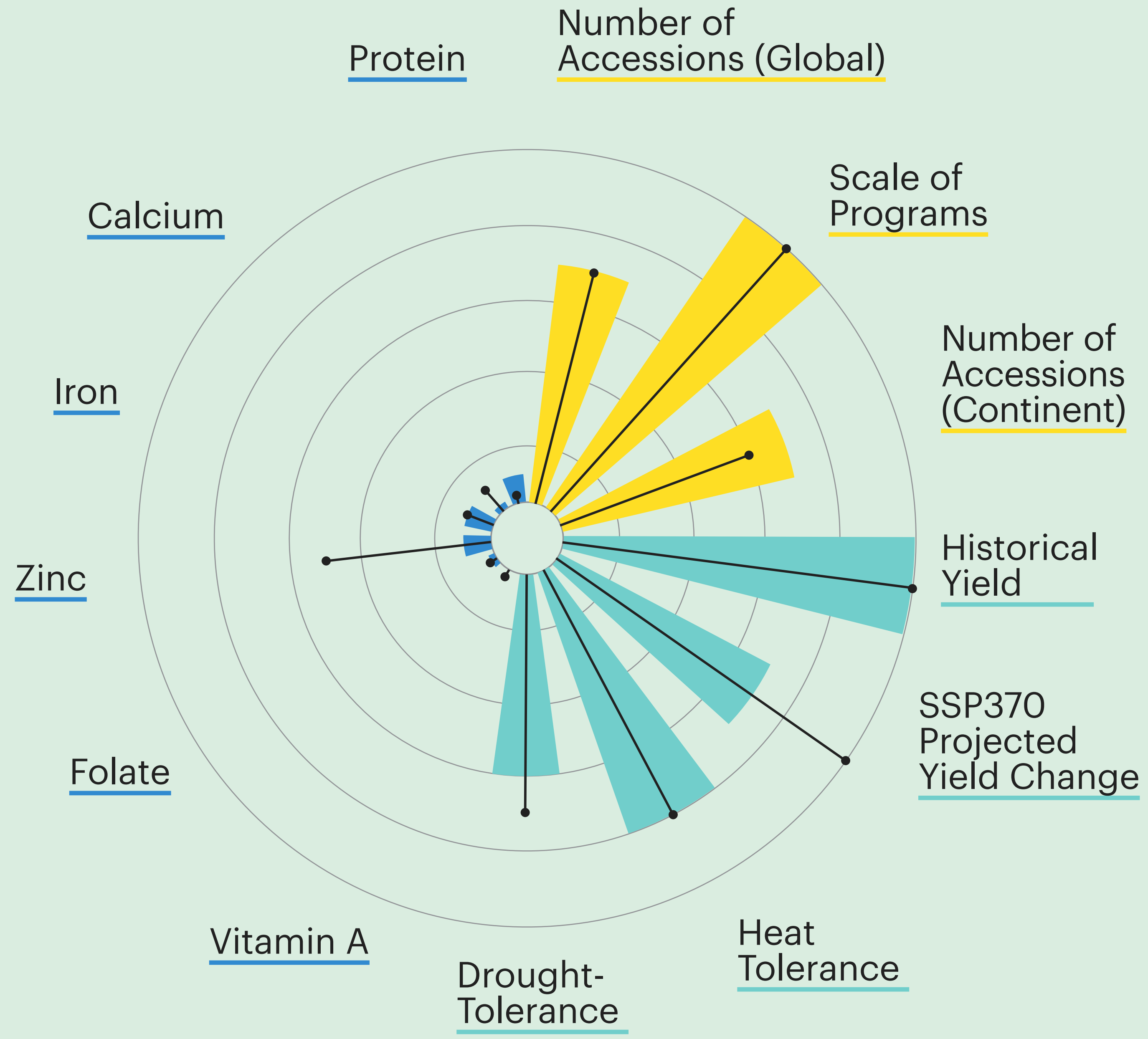
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Yam

## Climate Change Assessment

Yams have lower micronutrient levels than other opportunity crops but are very high yielding in general. Yams have a higher number of accessions globally. The number of continent-wide accessions is moderately large and higher than the reference crop cassava. Yams are drought- and heat-tolerant and are expected to see a slight increase in overall projected yield change across the continent. Yams are projected to sharply decrease in yield across the Sahel and are also projected to increase in yield across Eastern Africa.

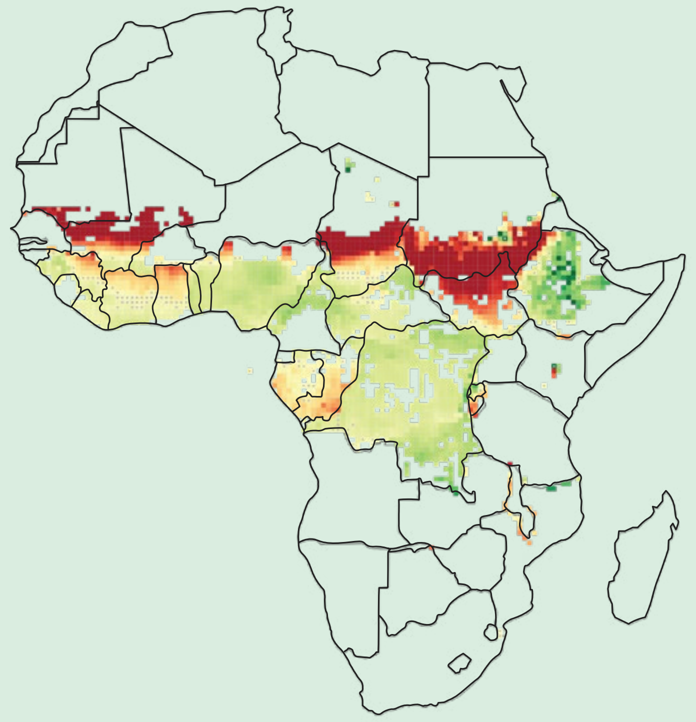
## Adaptation Indicators



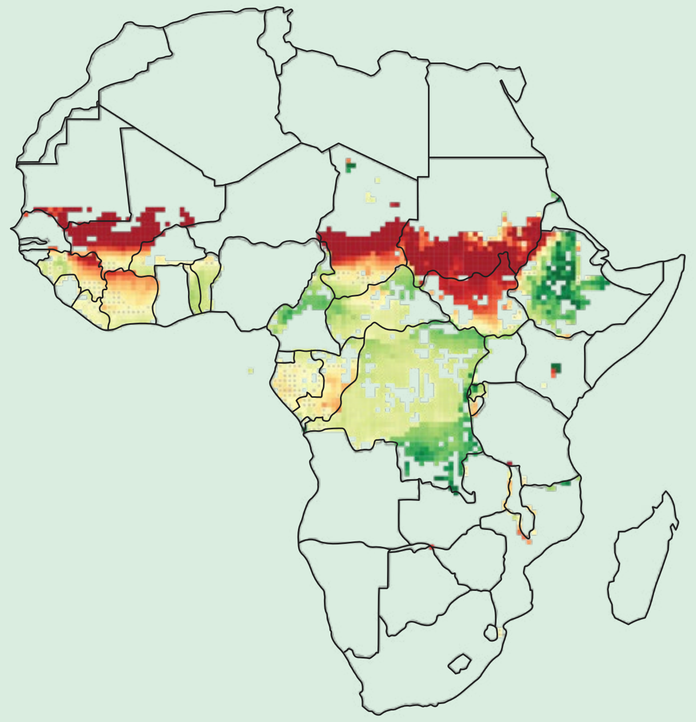

| | |
|---|---|
| Nutritional | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**



**% Change in Yield**

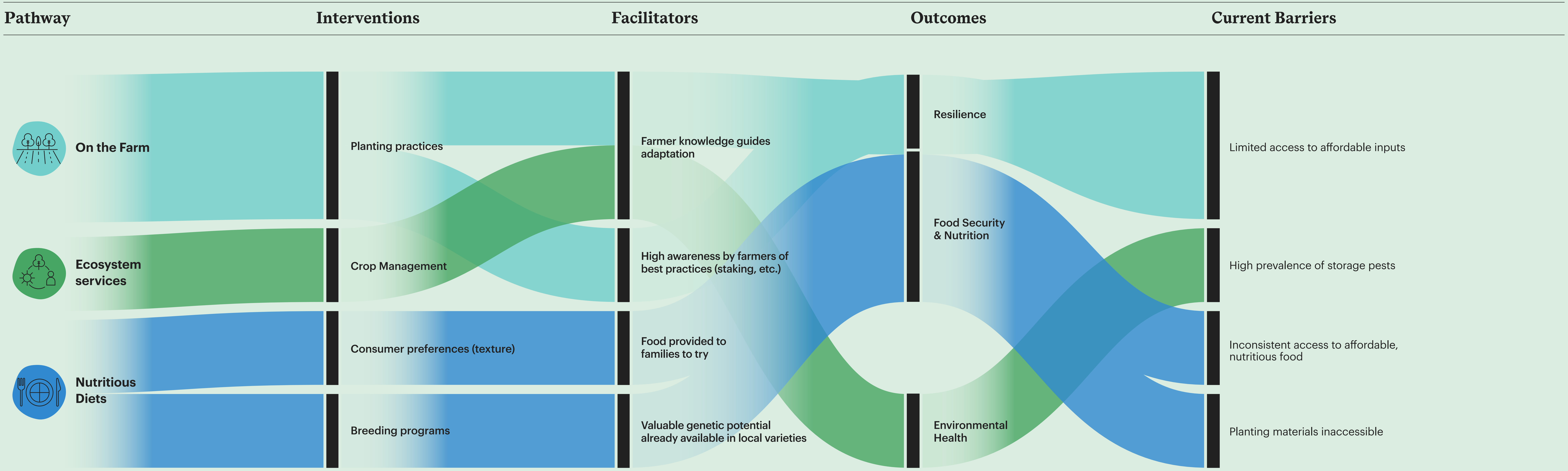
Model disagreement

| 50 | 25 | 0 | -25 | -50 |
|---|---|---|---|---|

# **Yam** Intervention Pathways

Areas of research interest supporting yams focus on crop management practices to improve mulching and tillage practices. Several studies emphasized opportunities to identify climate resilient yam species for warming and wetter climates. There is also research underway to determine the nutritional density of yams. Specific barriers to implementation include high-quality knowledge on nutritional properties, as well as advisory and extension information on climate adaptation strategies for yam farmers.

Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental



> “Sweet potato is nutritionally important across Africa. Leaves are also eaten in Tanzania.”
>
> *Expert plant breeder*

# Sweet Potato *Ipomea batatas*

## Opportunity Crop Profile

Sweet potato, widely cultivated in Africa, notably in countries like Nigeria, Uganda, and Tanzania, is a crop valued for its hardiness and adaptability. It thrives in various environmental conditions, from semi-arid to tropical climates, and produces in diverse soil types, including marginal soils with limited fertility. Sweet potatoes are particularly drought-tolerant, making them a viable crop choice in areas with inconsistent rainfall patterns.

Cultivation of sweet potatoes is predominantly done in small plots and often by women. It has been expanding due to shifts in cropping patterns due to major disease problems in other crops such as cassava and banana, declining farm sizes, economic volatility, and growth in commercial production. Sweet potatoes have a relatively short growing period, allowing for multiple harvests within a year. This characteristic is advantageous for smallholder farmers, offering a flexible cropping cycle and a rapid return on investment. However, sweet potatoes are susceptible to pests and diseases, such as sweet potato weevils and viral infections, which can impact yield and quality.

Orange fleshed varieties of sweet potatoes are a significant source of carbohydrates, as well as being high in beta-carotene (which the body converts to vitamin A), vitamin C, and dietary fiber. Sweet potatoes are used in a variety of dishes ranging from boiled or roasted tubers to processed forms like flour.

## Key Features

- Climate-resilient yield potential
- Drought-tolerant
- Relative high concentration of Vit. A
- Cultural significance
- Evidence of women’s empowerment
- High consumer acceptance
- High Value Chain Potential
- Genomic sequencing completed or underway

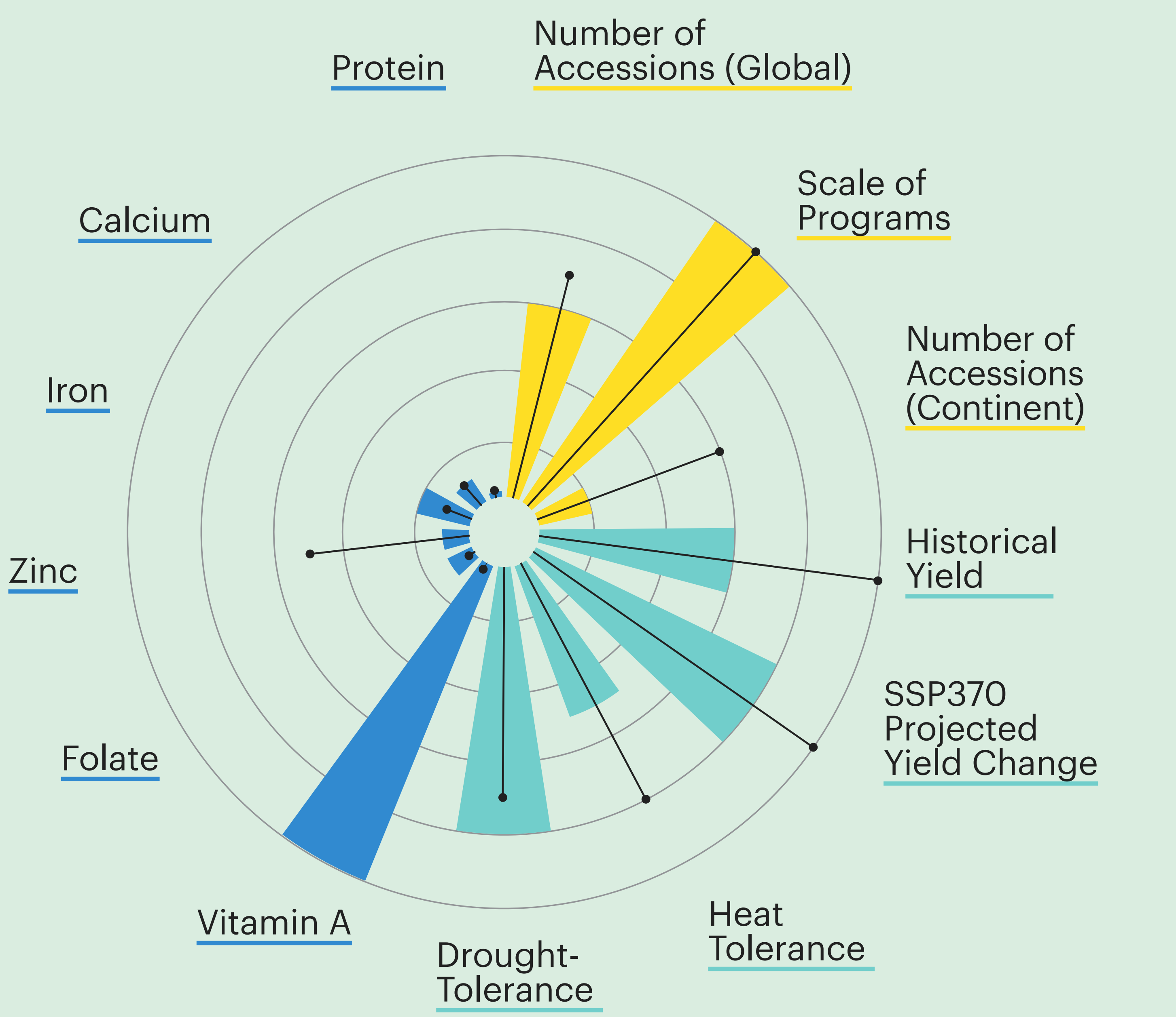
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Sweet Potato

## Climate Change Assessment

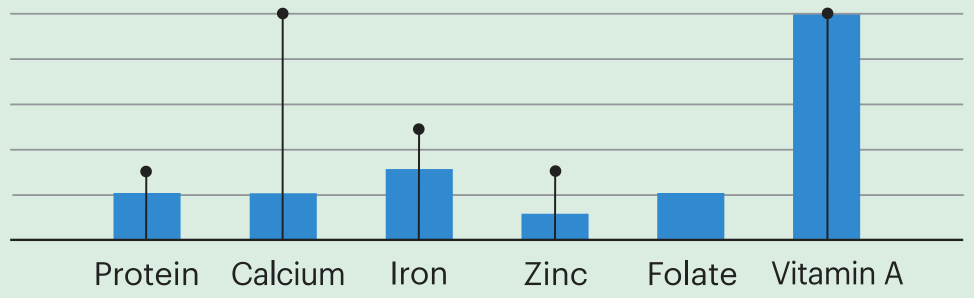
Orange fleshed varieties of sweet potato tubers have extremely high vitamin A levels. Sweet potato leaves have higher levels of protein, calcium, iron and folate than tubers. Sweet potato has a moderate number of global accessions and enjoy globalized and continent-wide breeding programs. Its number of continent-wide accessions is low, however, especially compared to the reference crop cassava. Sweet potato is very drought-tolerant and moderately heat-tolerant and is expected to increase overall projected yield change across the continent from a moderate historical yield. Under both low and high emissions scenarios, there is a decrease in yield in Western Africa, an increase in Central-Eastern Africa, and mixed results in Southern Africa depending highly on localized geography.

## Adaptation Indicators




**Sweet Potato Leaf Nutrition**

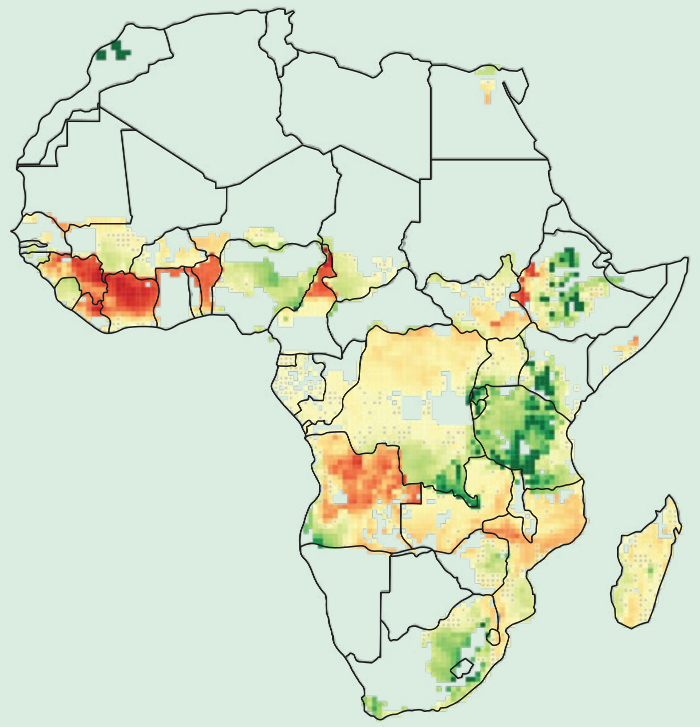
Reference/Comparator Crop: Cassava Leaves



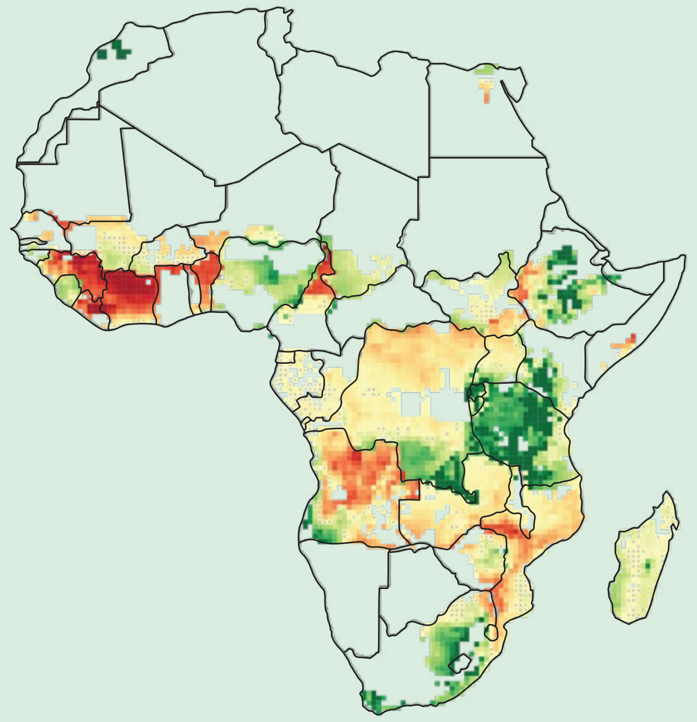

| | |
|---|---|
| Nutritional | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



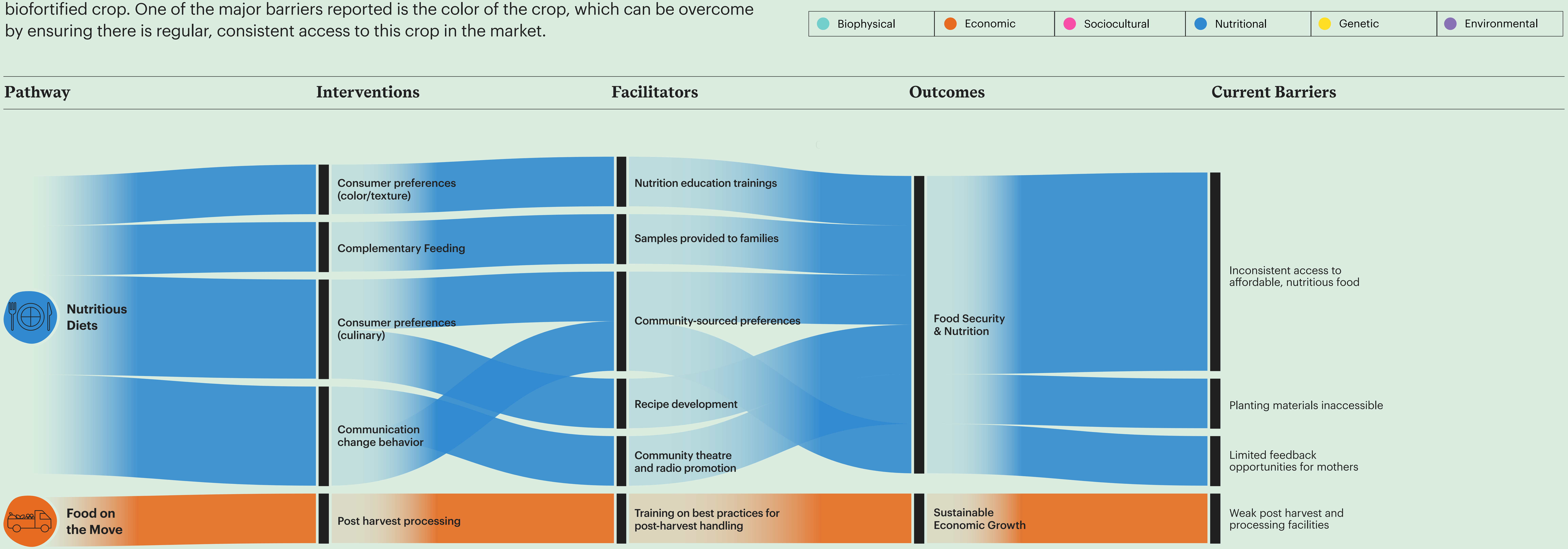
**SSP3-7.0**
**High Emissions**



**% Change in Yield**

# **Sweet Potato** Intervention Pathways

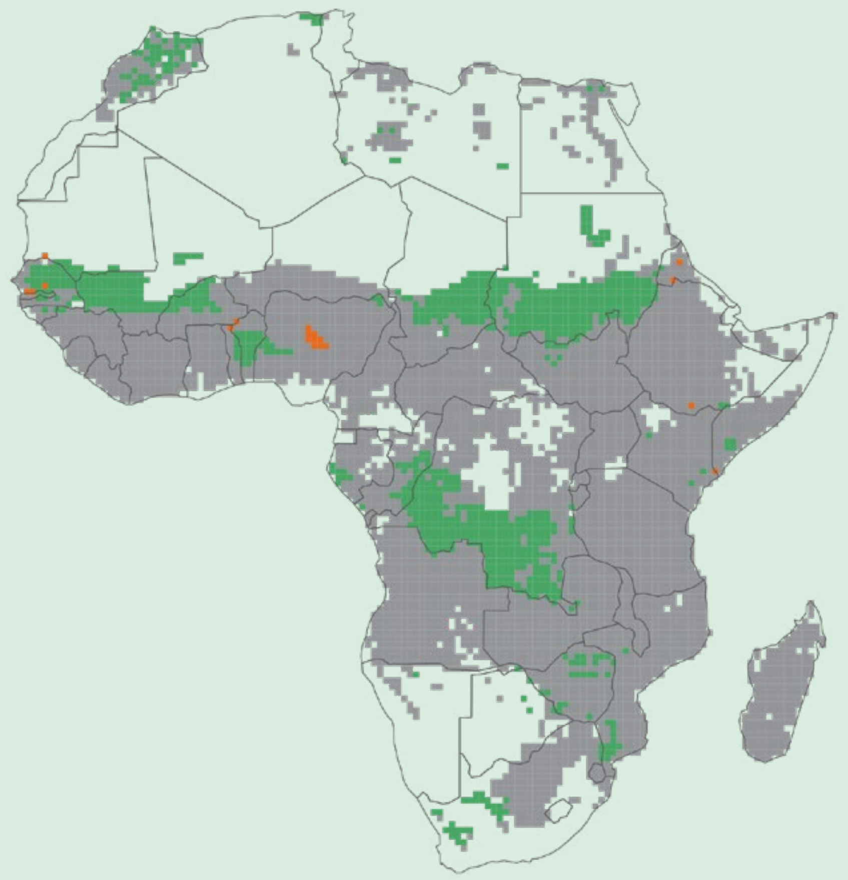
High-quality evidence on sweet potato focuses almost exclusively on downstream interventions to improve nutritional benefits, especially vitamin A. Well-designed interventions, including tastings, nutrition education, and family feeding trials are designed to explore consumer preferences of this biofortified crop. One of the major barriers reported is the color of the crop, which can be overcome by ensuring there is regular, consistent access to this crop in the market.



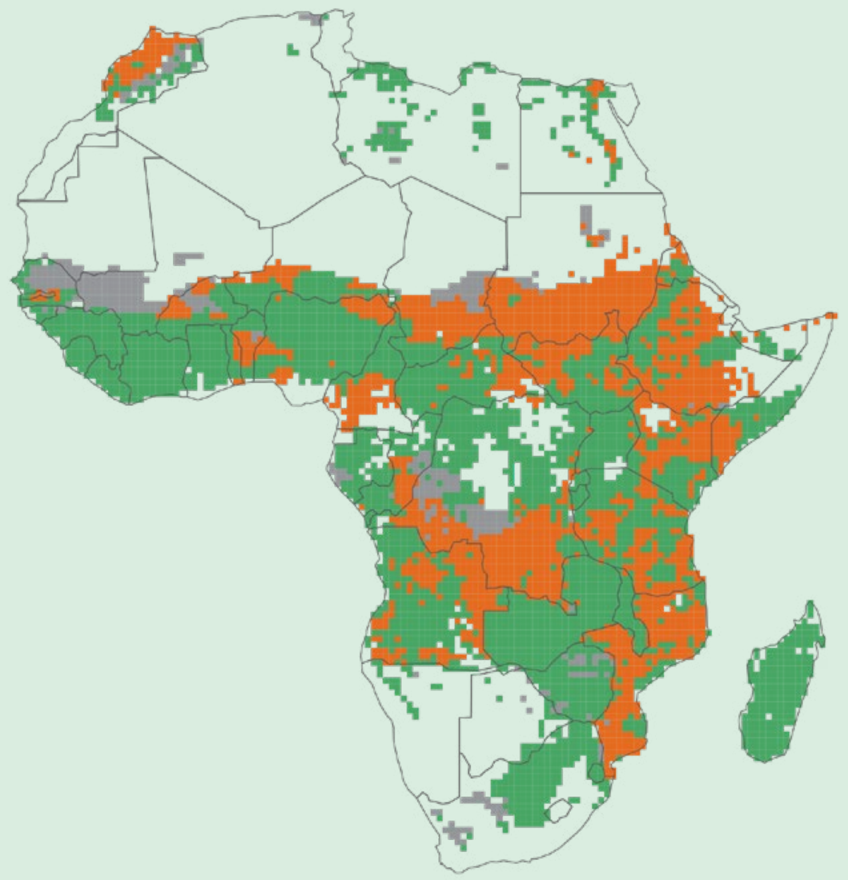

## Summary of Climate-Crop Modeling Results

This figure displays the combined yield change projections for all the nuts and oilseeds that AgMIP has modeled to date (groundnut is included in this food basket category, despite it technically being a legume). Both groundnut and sesame are poised to be resilient under high emissions climate change scenarios across the continent, with potential decrease in productivity for groundnut in Sahelian zones and Central Africa.

**Largest Yield Decrease**
SSP3-7.0 – High Emissions



**Largest Yield Increase**
SSP3-7.0 – High Emissions



**Oilseeds**

| None | Groundnut | Sesame |
| --- | --- | --- |

# Sesame *Sesamum indicum*

## Opportunity Crop Profile

Sesame is a widely cultivated oilseed crop, particularly prominent in various countries, including Sudan, Nigeria, and Ethiopia. Sesame has drought-resistant properties, making it suitable for cultivation in arid and semi-arid regions. Sesame thrives in a range of soil types, though it prefers well-drained, fertile soils. It is typically grown in areas with limited rainfall, capitalizing on its ability to produce viable yields in challenging climatic conditions.

Sesame's resilience to drought is accompanied by a sensitivity to water logging, necessitating careful water management. The crop has a relatively short growing period, ranging from 85 to 125 days, allowing for timely harvesting and flexibility in crop rotation. However, sesame has lower pests and disease tolerance, which can impact yield and quality.

Sesame seeds are used in various forms—whole, ground into paste, or extracted for oil. The economic importance of sesame, combined with its adaptability to harsh environmental conditions, makes it a significant crop for both smallholder and commercial farmers in Africa.

> **"Few breeding populations. Important nutritionally (omega 3s) and as a cash crop."**
>
> *Expert plant breeder*

### Key Features

- High Value Chain Potential
- High consumer acceptance
- Evidence of women's empowerment
- Relative high concentration of Calcium
- Relative high concentration of Iron
- Genomic sequencing completed or underway
- Climate-resilient yield potential
- Drought-tolerant
- Heat-tolerant

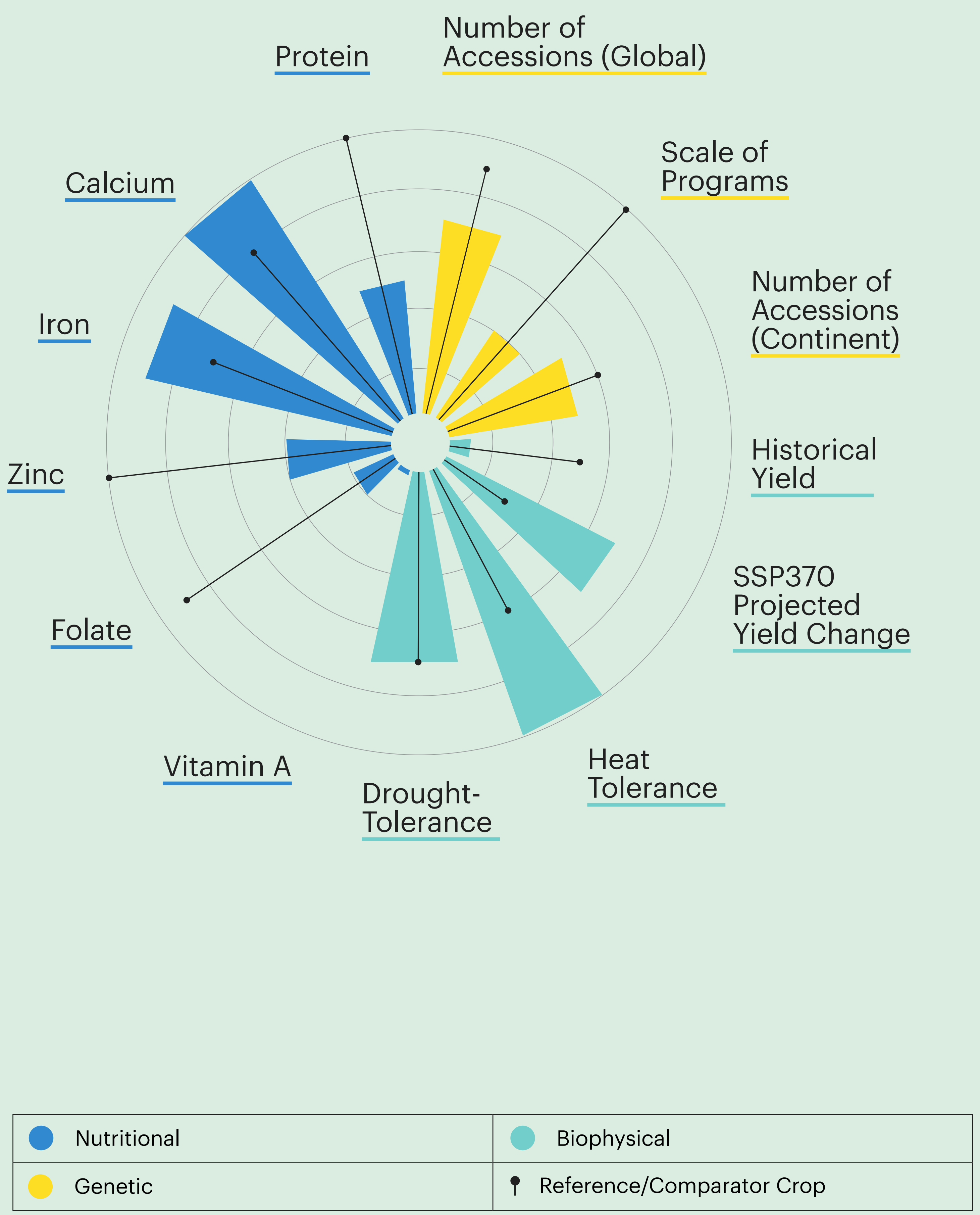
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Sesame

## Climate Change Assessment

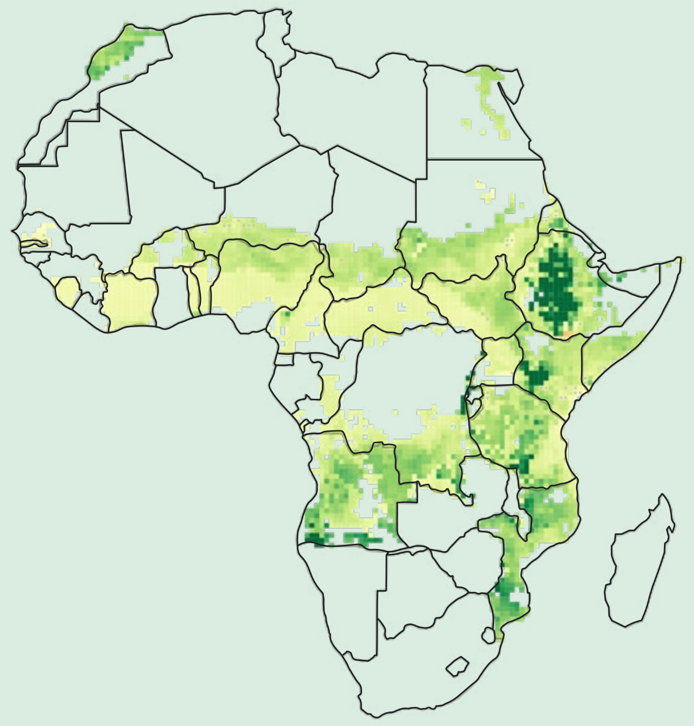
Sesame is higher in calcium and iron than soybean. It has trace amounts of vitamin A. Sesame has a high number of global accessions and a country-level scale of genetic research programs. Its number of continent-wide accessions is slightly below average. Sesame is drought-tolerant and very heat-tolerant and is expected to increase overall projected yield change across the continent from a low historical yield. Under both low and high emissions scenarios, there is an increase in yield change in Western, Central, and especially many parts of Eastern Africa.

## Adaptation Indicators

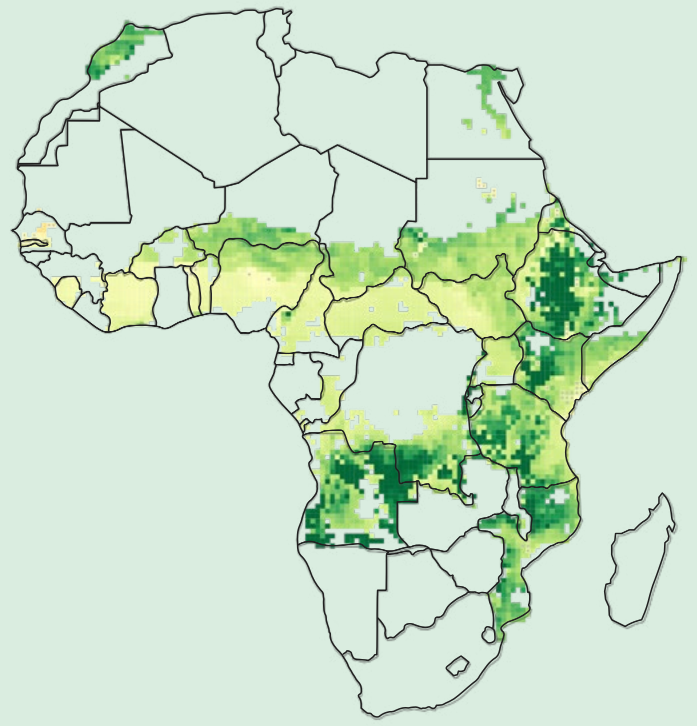



## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



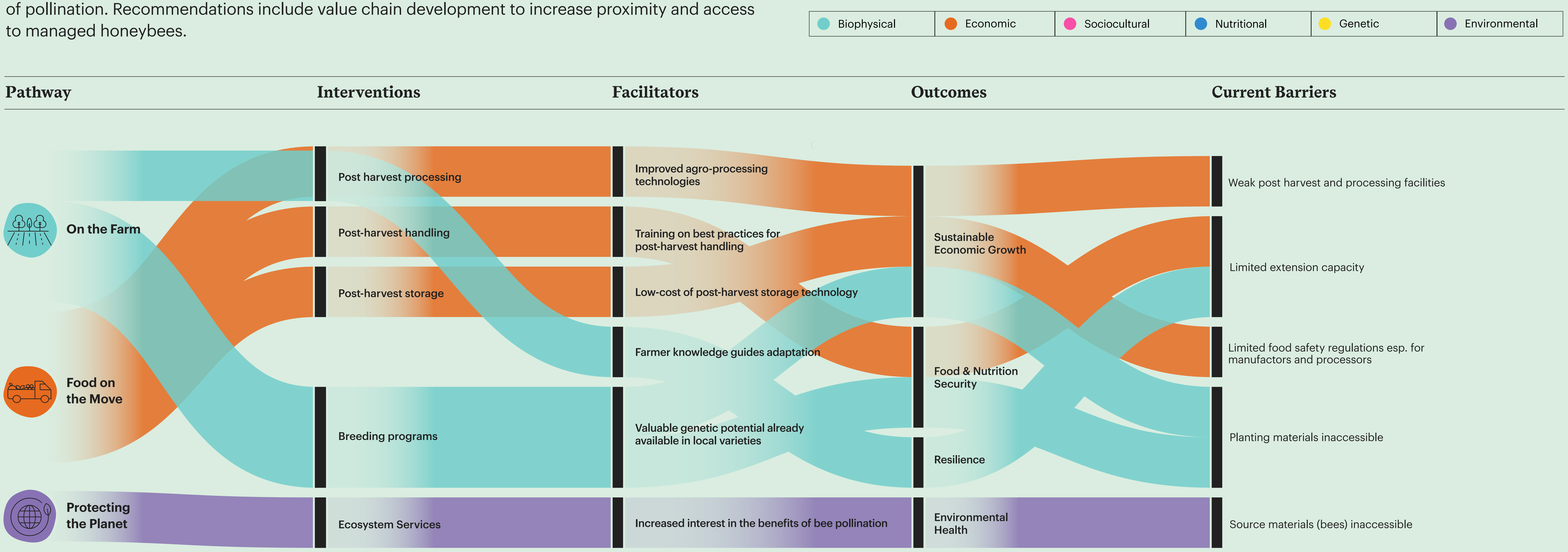
**SSP3-7.0**
**High Emissions**



**% Change in Yield**

# **Sesame** Intervention Pathways

Evidence on sesame emphasizes opportunities to improve food and nutrition security outcomes, as well as economic growth, through improved technologies and post-harvest handling practices. Interventions include working with manufacturers to develop best practices to support food safety. In addition, sesame is one of the few crops that highlights ecosystem services dedicated to the benefits of pollination. Recommendations include value chain development to increase proximity and access to managed honeybees.



# Groundnut *Arachis hypogea*

## Opportunity Crop Profile

Groundnut, also known as peanut, is a significant crop in many African countries, including Nigeria, Senegal, Sudan, and Ghana. It is one of the continent's most important oilseed crops, valued not only for its nutritional properties but also for its economic potential. Groundnuts are cultivated extensively in both commercial and smallholder farming settings, often under rainfed conditions, and play a vital role in the agricultural economies of these regions. The African continent accounts for 24% of the global production, providing protein, edible oil, minerals, vitamins, and dietary fiber.

Groundnuts are grown in a variety of soil types but prefer well-drained sandy loam soils. They are sensitive to waterlogging and therefore require adequate drainage for optimal growth. While groundnuts are relatively drought-tolerant, consistent moisture is necessary during the initial growth period and around flowering for optimal yield. One key challenge in groundnut cultivation is the susceptibility to diseases and pests, notably groundnut rosette virus and aflatoxin contamination, which can significantly impact both yield and quality.

Groundnuts are a rich source of energy, high-quality protein, and healthy fats. They are also high in vitamins, particularly niacin, and minerals like magnesium, phosphorus, and potassium. Groundnuts are consumed in various forms – raw, roasted, boiled, and as an ingredient in numerous dishes. They are also processed into oil, and into groundnut paste or butter, commonly used in sauces and soups.

**"Many international resources with moderate recent investment. PGR available. Aflatoxin a major issue to solve."**

*Expert plant breeder*

## Key Features

- High yielding under current climate
- Climate-resilient yield potential
- Heat-tolerant
- Supports animal and livestock health
- Relative high concentration of Zinc
- Relative high concentration of protein
- Contributes to soil health
- Nutrient use efficiency
- High plant genetic resources globally
- High plant genetic resources in Africa
- Genomic sequencing completed or underway
- High Value Chain Potential

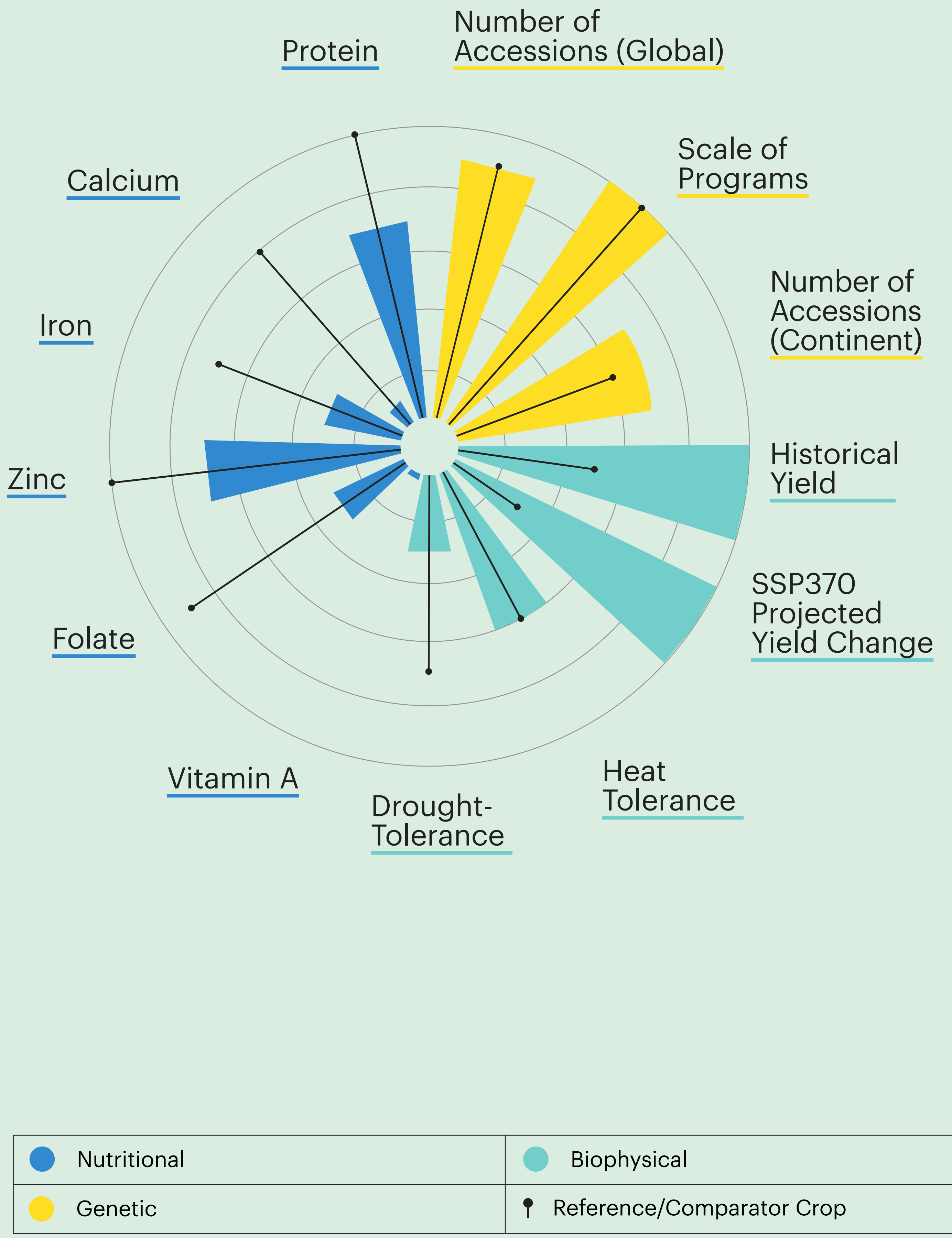
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Groundnut

## Climate Change Assessment

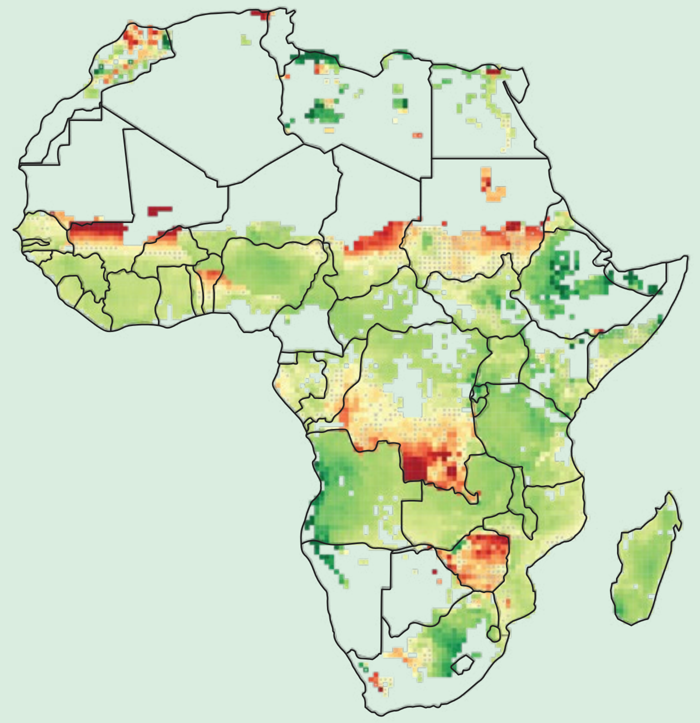
Groundnut has slightly above-average micronutrient levels of protein and zinc but lower folate and iron levels. It has trace amounts of calcium and vitamin A. Groundnut has a large number of global accessions and a globalized breeding program. Its number of continent-wide accessions is above average but can still be expanded upon. Groundnut has relatively low drought-tolerance and moderate heat-tolerance. Groundnut is expected to see an overwhelming projected yield change under climate change from an already high historical yield. We can see this across the continent in Western, Eastern, Central, and Southern Africa, with exceptions where there are sharp decreases in yield change along the Sahel and in some parts of Central Africa.

## Adaptation Indicators

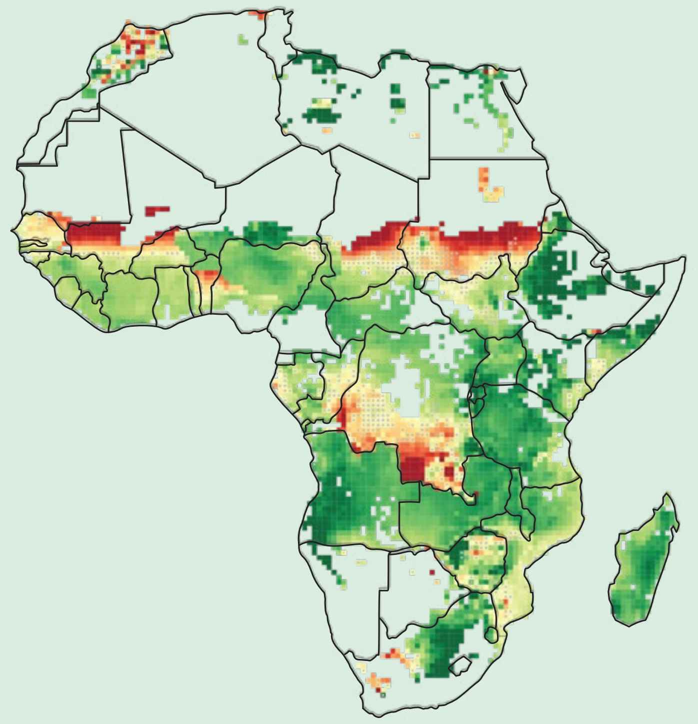



## Yield Projections under Climate Change

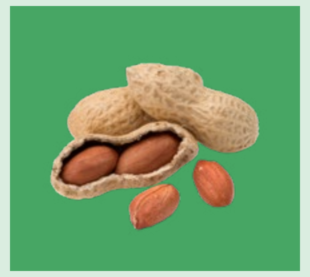
**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**



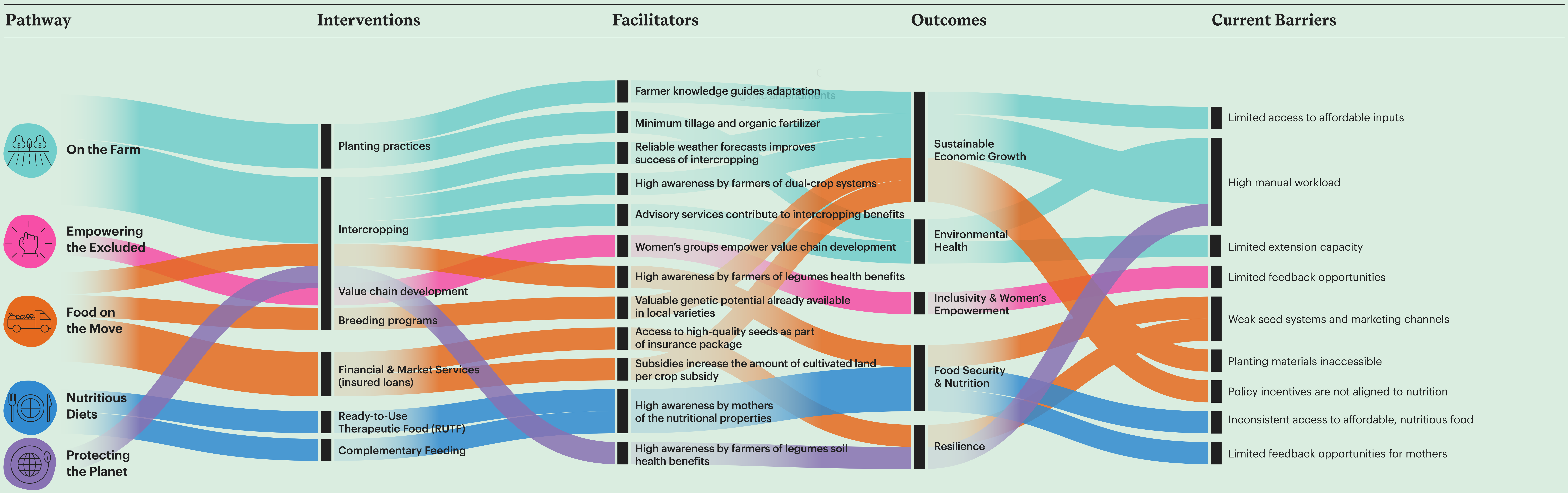
**% Change in Yield**



# **Groundnut** Intervention Pathways

Groundnut interventions emphasize value chain development, food-based interventions, and crop management. There is high awareness by mothers and caregivers of the nutritional properties of groundnuts and groundnut-based products. Access to quality seeds, and the need for access to improved varieties on a routine basis, is highlighted as a critical need by farmers. In addition, this intervention pathway highlights the opportunities for subsidies for traditional crops to change land use.

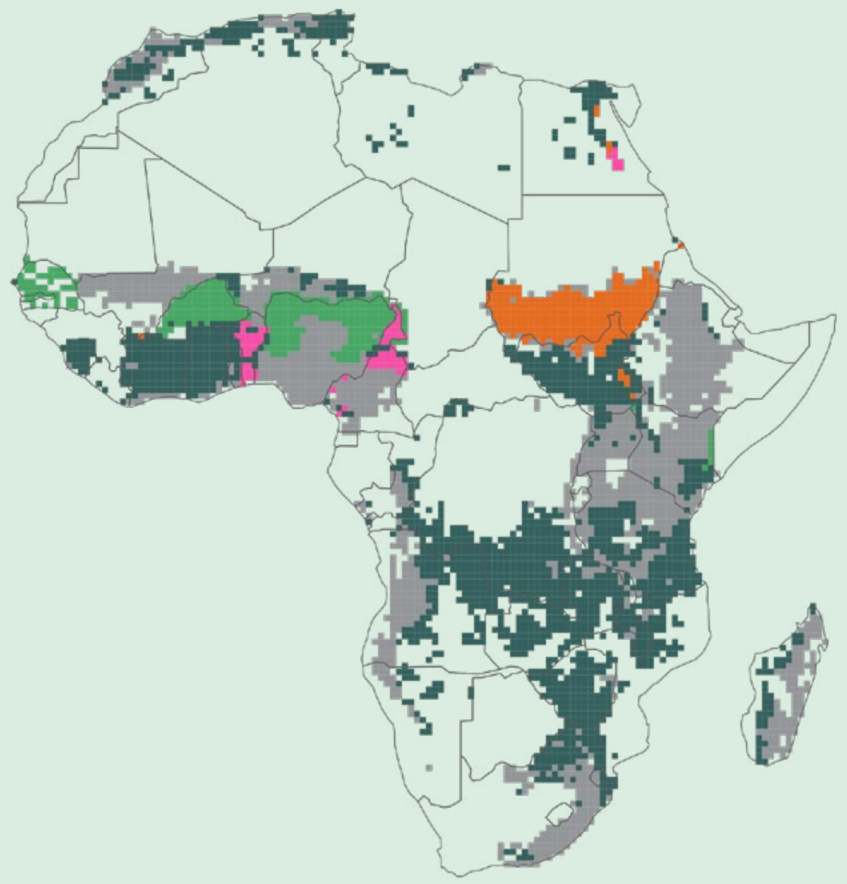
| Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental |
|---|---|---|---|---|---|



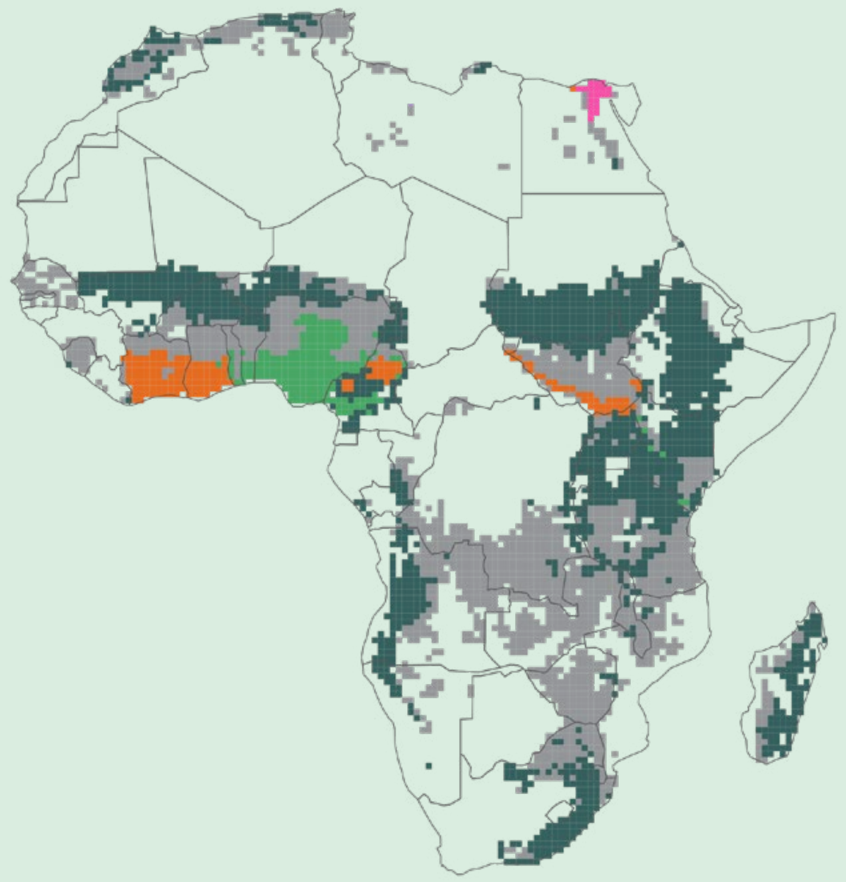

## Summary of Climate-Crop Modeling Results

This figure displays the combined yield change projections for all the annual fruits and vegetables that AgMIP has modeled to date. Tomato is projected to decrease in productivity in many areas in Western, Central, and Northern Africa, with African eggplant being vulnerable in parts of East Africa. Tomato is poised to be resilient under high emissions climate change scenarios in East Africa and Southern Africa however, and okra shows promise to be resilient in large swaths of West Africa.

**Largest Yield Decrease**
SSP3-7.0 – High Emissions



**Largest Yield Increase**
SSP3-7.0 – High Emissions



**Vegetables**

| | | |
|---|---|---|
| None | Tomato | Okra |
| African eggplant | Joseph's coat | |

# African Eggplant *Solanum aethiopicum/macrocarpon*

**“The wide genetic available in germplasm collection...makes it important for breeding. Its potential for livelihood improvement is high. Both species can serve as sources of resistance to bacterial wilt for other susceptible crops within the same family, such as eggplant.”**

*Expert plant breeder*

## Opportunity Crop Profile

African eggplant comprises a group of widely cultivated varieties across Africa and are a significant crop grown from southern Senegal to Nigeria, across Central to Eastern Africa, and down to Angola, Zimbabwe, and Mozambique. African Eggplants are known for their vibrant colors, ranging from white, cream, yellow, and green, to purple and black, often with glossy, multi-colored skins. Their relatively short cultivation cycle and low maintenance requirements make them suitable for both small-scale subsistence farming and larger agricultural operations.

African eggplants thrive in warm and tropical climates with temperatures between 21°C to 32°C and are adaptable to regions with consistent rainfall but can tolerate short dry periods. These plants exhibit relative resistance to certain pests and diseases like aphids and whiteflies, although they may face challenges from spider mites and fruit flies. African Eggplants thrive in well-drained, fertile soils with a pH level between 6.0 and 7.0. Soil enriched with organic matter is crucial for their growth, and regular soil testing aids in maintaining soil health.

Harvesting African eggplants involves picking the fruits while still immature, approximately 70-90 days after sowing. The harvesting process continues over 8-10 weeks, with the potential yield being significant; for instance, three plants grown on a small plot can produce up to 10 kilograms of fruits. Additionally, different horticultural techniques are used for the production of leaves, which involves regular harvesting and de-budding to encourage the growth of side shoots, extending the harvesting period.

## Key Features

- High Value Chain Potential
- High consumer acceptance
- High yielding under current climate
- Drought-tolerant
- Pest-resistant
- Disease-resistant

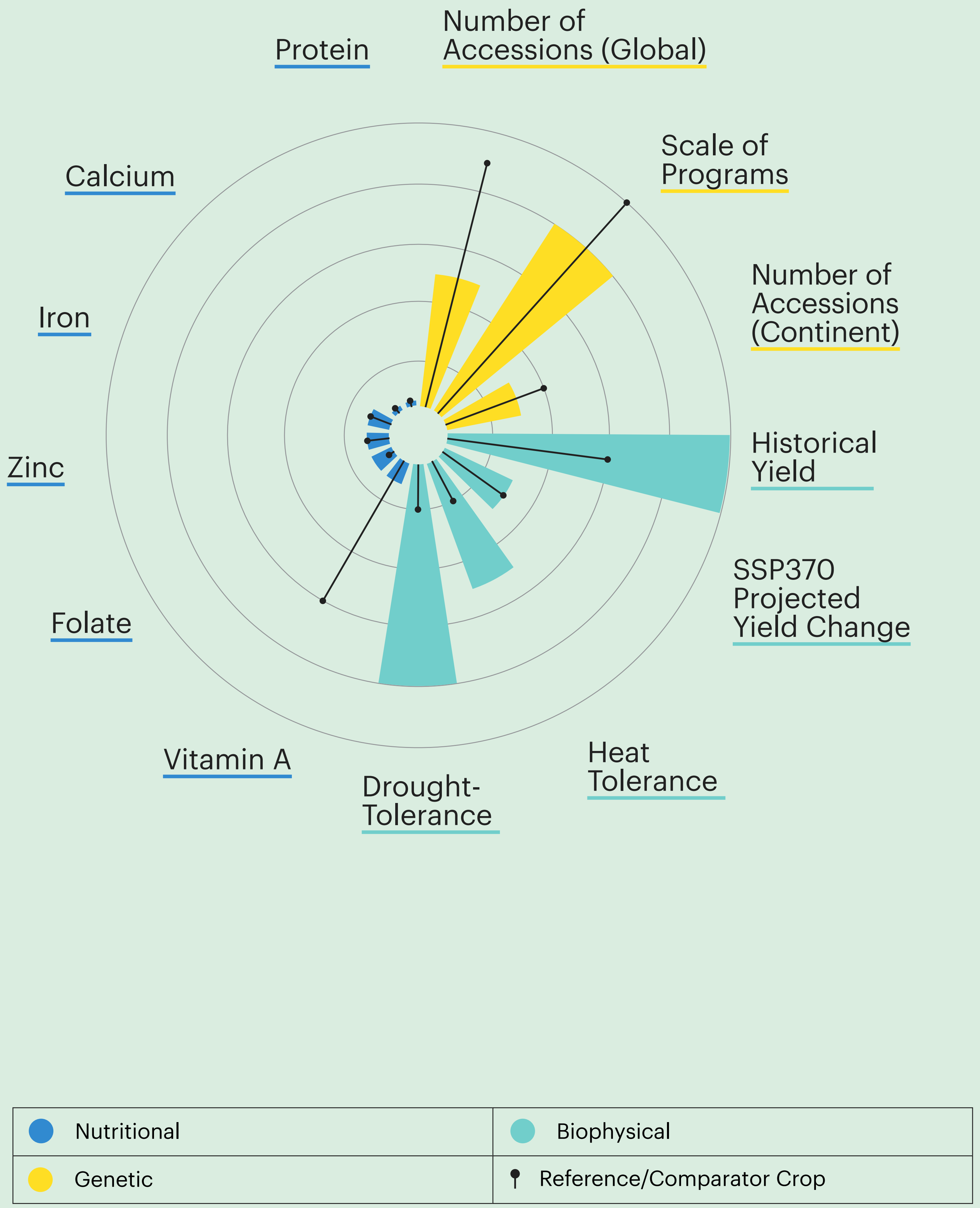
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# African Eggplant

## Climate Change Assessment

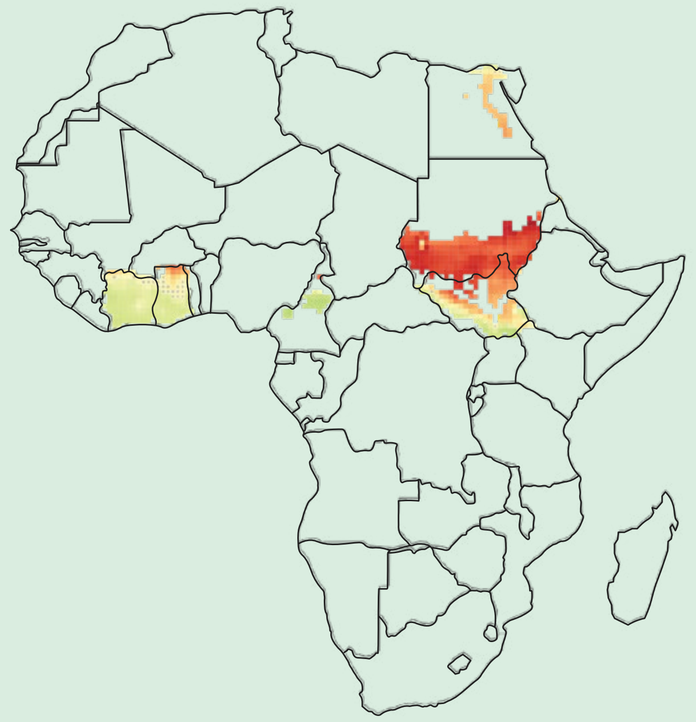
African eggplant has a lower micronutrient composition across the board for protein, calcium, iron, zinc, folate, and vitamin A than many other opportunity crops. African eggplant has a moderate number of global accessions and a continent-wide degree of genetic research programs. Its number of continent-wide accessions is low. African eggplant is very drought-tolerant and moderately heat-tolerant and is expected to decrease overall projected yield change across the continent from a very high historical yield. Under both low and high emissions scenarios, there is a sharp decrease in yield change in Eastern Africa and along the Nile in Egypt, and mixed results in Western Africa depending on localized context. It is important to note that spatially explicit data on African eggplant production were limited, and that it is possible that modeling African eggplant in other geographies would lead to more climate-resilient projections overall.

## Adaptation Indicators

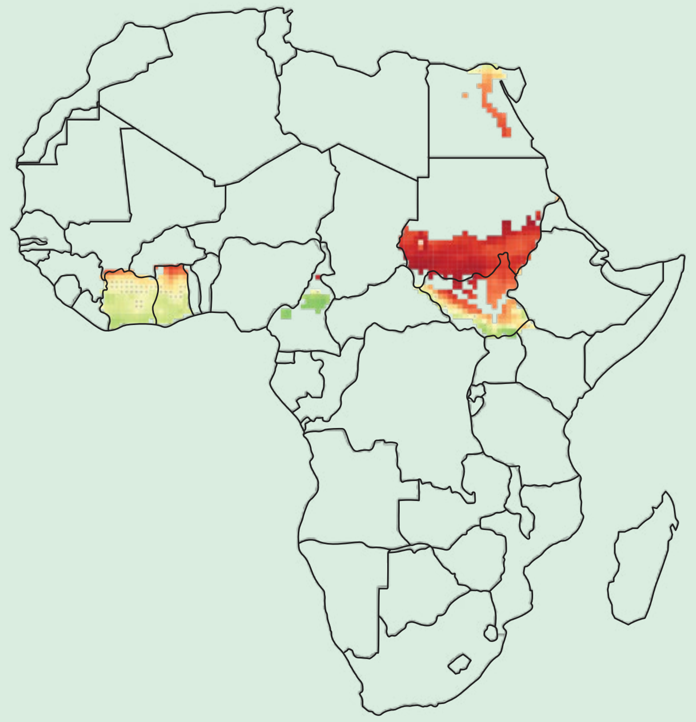



## Yield Projections under Climate Change

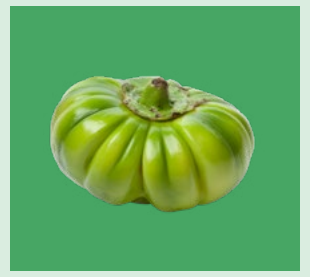
**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**



**% Change in Yield**

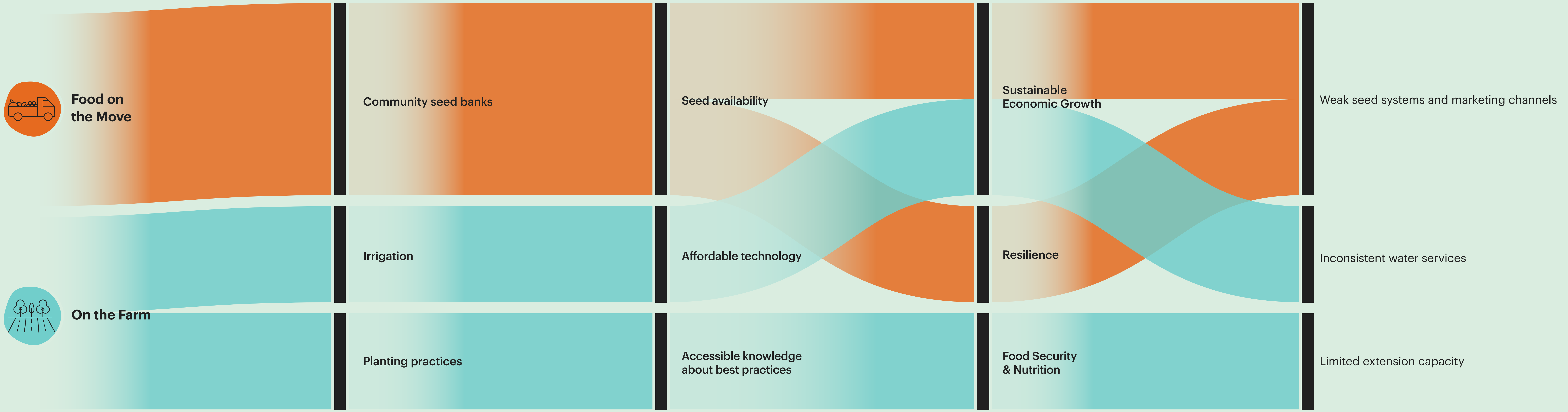


# **African Eggplant** Intervention Pathways

Evidence on African eggplant is relatively limited, but studies highlight the importance of early taste exposure opportunities for children as part of complementary feeding programs. Community seed banks play an important role for farmers to access high-quality, affordable seeds to limit the frequency of seed ‘recycling’ by farmers. Policy interventions are urgently needed to help transform the seed sector.

| Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental |
|---|---|---|---|---|---|

| Pathway | Interventions | Facilitators | Outcomes | Current Barriers |
|---|---|---|---|---|



# Amaranth *Amaranthus* spp.

## Opportunity Crop Profile

Joseph's Coat, commonly known as Amaranth, is predominantly grown in countries such as Nigeria, Ghana, Côte d'Ivoire, and Benin. Amaranth boasts vitamin A, iron, and calcium content and is often used as a vegetable in traditional dishes. It thrives in a variety of soil types, including those that are less fertile, and is resilient to drought and other harsh climate conditions prevalent in many parts of the continent. This hardiness makes amaranth a dependable crop in uncertain environmental conditions, ensuring a consistent food source where other crops might fail. In addition, its rapid growth cycle and minimal resource requirements make it a favorable choice for enhancing food security and supporting local economies.

Amaranth prefers warm and tropical climates, with optimal temperatures ranging from 70°F to 90°F (21°C to 32°C). Adequate and evenly distributed rainfall, typically in the range of 900 to 1200 mm (35 to 47 inches) annually, is crucial for its growth, making it well-suited to regions with consistent rainfall. Amaranth thrives in soils with good drainage, favoring sandy loam or loamy textures, and a slightly acidic to neutral pH level (6.0 to 7.0).

> "The crop (as vegetable and grain) has high potential for nutrition security and livelihood improvement. Consumer demand is increasing. Excellent potential with good base resources and several programs."

*Expert plant breeder*

### Key Features

- High yielding under current climate
- Drought-tolerant
- Relative high concentration of Calcium
- Relative high concentration of Iron
- High lean season value
- Cultural significance
- Relative high concentration of Vit. A
- Water use efficiency (WUE)
- High consumer acceptance
- High Value Chain Potential
- Genomic sequencing completed or underway

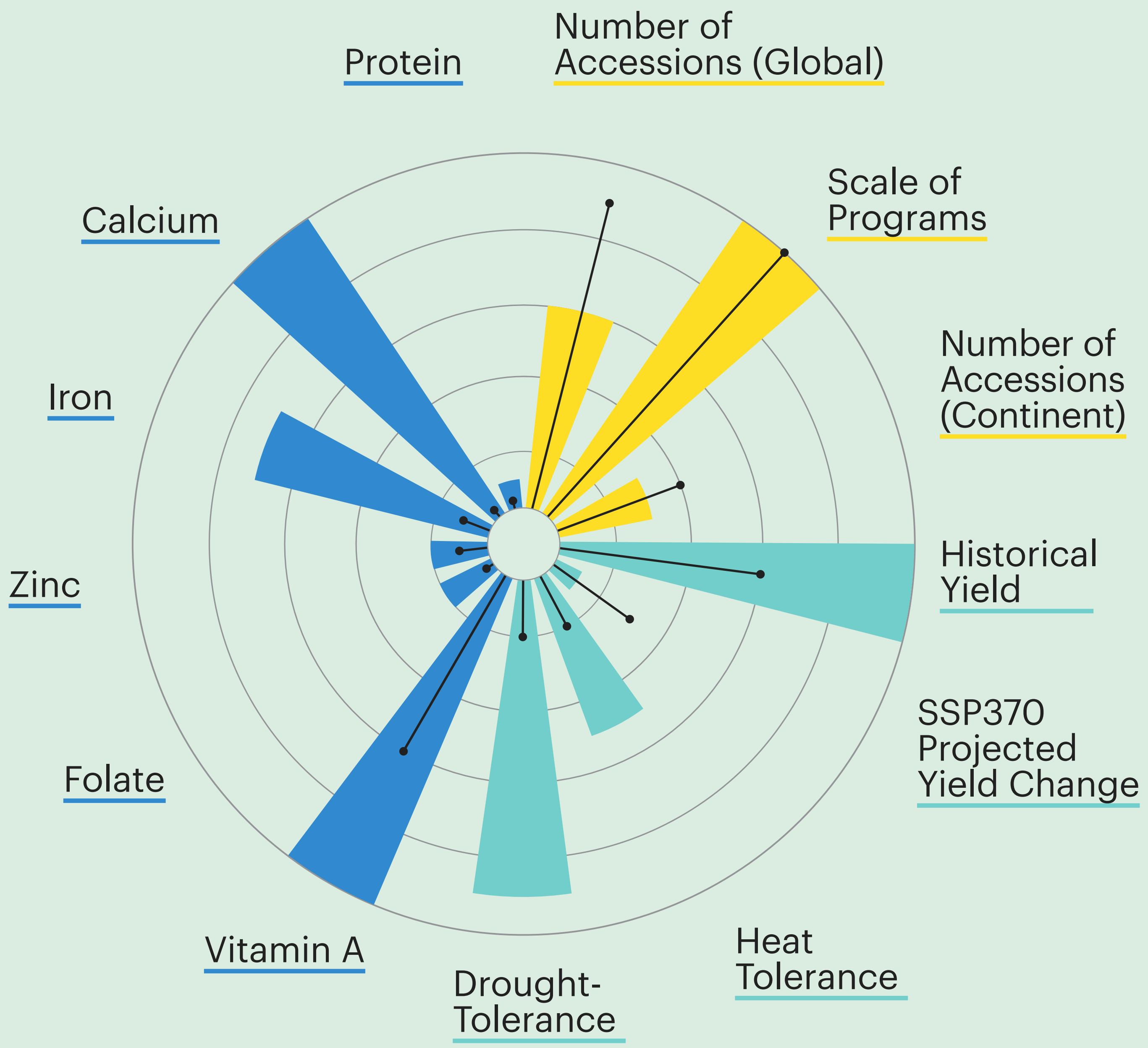
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Amaranth

## Climate Change Assessment

Amaranth leaves are highly nutritious in calcium, vitamin A, and, to a lower but still significant extent, iron. Amaranth has lower levels for protein, zinc, and folate than many other opportunity crops but is still higher than that of the reference crop (tomato). Amaranth has a moderate number of global accessions and a continent-wide degree of genetic research programs. Its number of continent-wide accessions is low. Amaranth is very drought-tolerant and moderately heat-tolerant. Under both low and high emissions scenarios, there is a decrease in yield in Western Africa and neutral to positive projections along the Nile river basin in Egypt. It is important to note that spatially explicit data on amaranth production were limited, and that it is possible that modeling amaranth in other geographies woud lead to more climate-resilient projections overall.

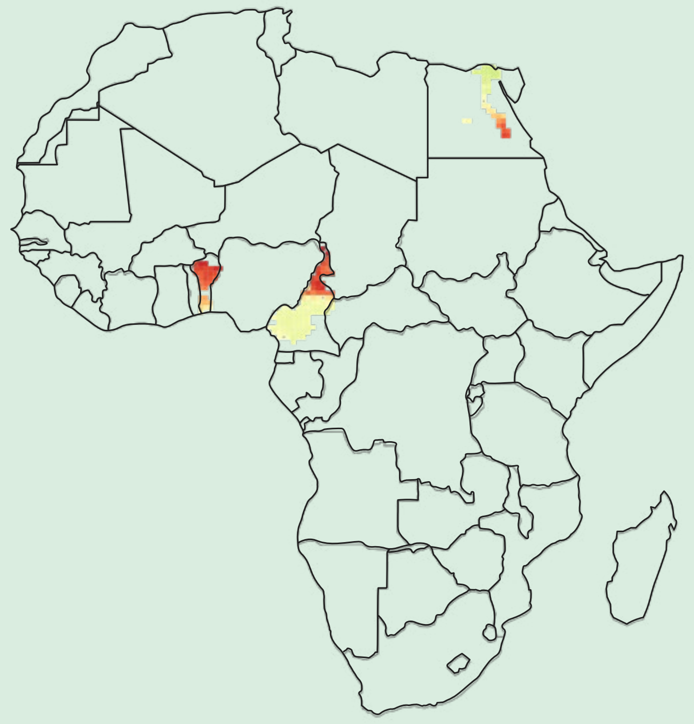
## Adaptation Indicators



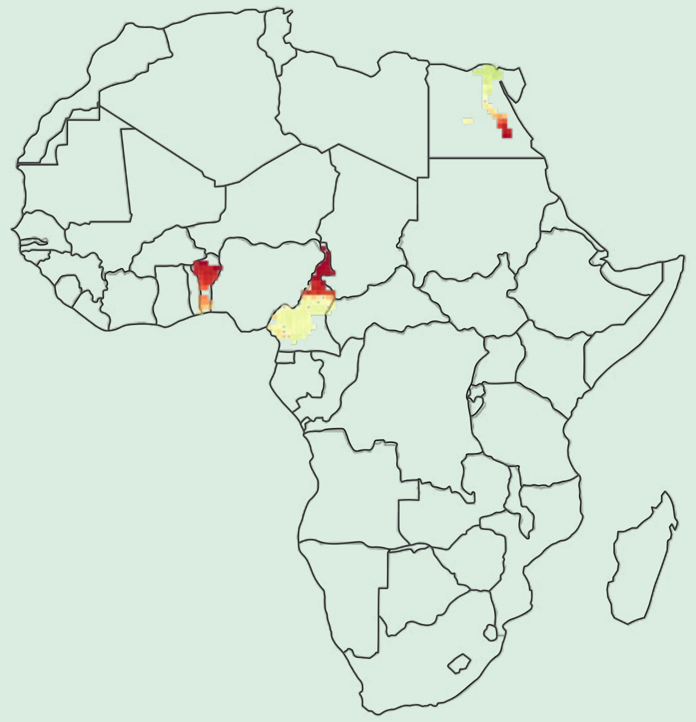

| | |
|---|---|
| Nutritional | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**

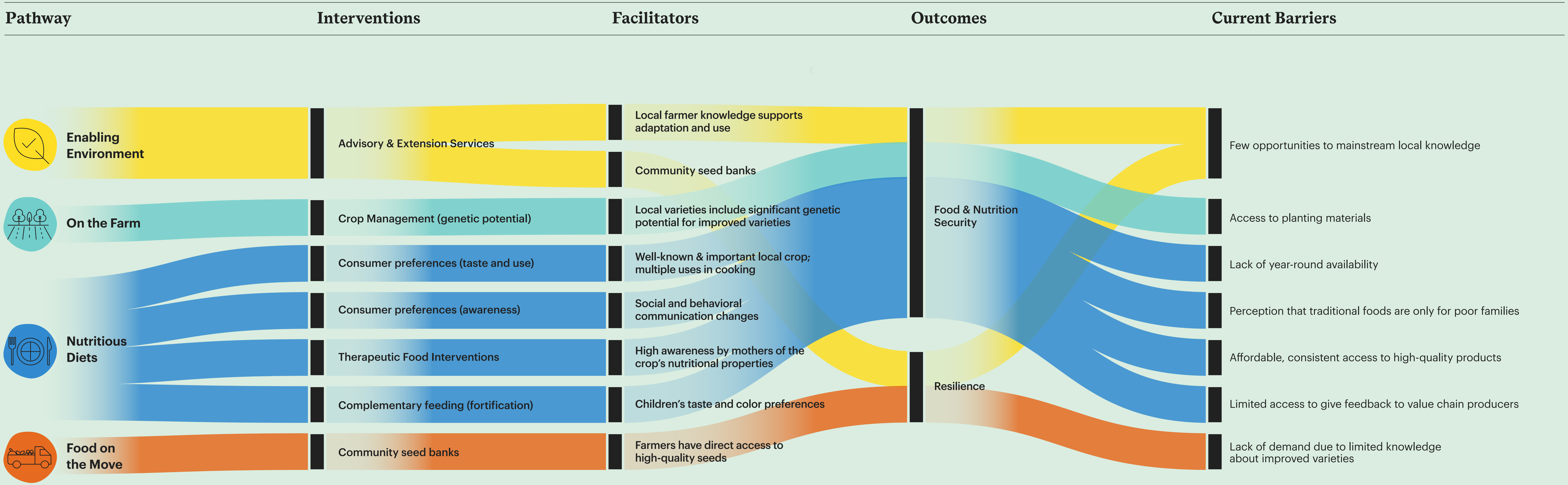


**% Change in Yield**

# **Amaranth** Intervention Pathways

Amaranth is a well-known and important local crop, especially for food and nutrition security. Mothers and caregivers are aware of its nutritional potential. Despite the nutritional potential, changing consumer perceptions of amaranth as a “lean season” or “poor family” crop is needed. Social and behavioral communication interventions, including nutrition education, can help change perceptions to scale up this crop.

Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental



# Okra *Abelmoschus* spp.

## Opportunity Crop Profile

Okra, a nutrient-rich vegetable crop, is predominantly grown in tropical and subtropical regions (e.g., Nigeria). The cultivation of okra is widespread due to its adaptability to various soil types, including well-drained sandy loam soils rich in organic matter, ideally with slightly acidic pH levels between 5.8 and 6.8 . The crop is generally self-pollinating and belongs to the Malvaceae family. It serves as a multipurpose and economically significant crop for farmers and marketers, especially in Nigeria, due to the income generated from selling immature fresh leaves and dried fruits which can be utilized in diverse soup products.

Moreover, the mature fruit and stems find application in the paper industry, and okra mucilage can be used as food additives. Efforts to genetically improve okra have been focused on responding to farmers' demands for improved varieties and optimizing for traits that respond to major constraints affecting okra productivity, including the lack of improved varieties, diseases, pests, and drought.

"High market demand [and] availability of genetic and genomic resources. Need for improvement of traits to meet market demand. Many local and national seed companies are requesting seed of quality varieties."

*Expert plant breeder*

### Key Features

High Value Chain Potential

High consumer acceptance

High yielding under current climate

Climate-resilient yield potential

Drought-tolerant

Disease-resistant

Relative high concentration of Vit. A

Cultural significance

Genomic sequencing completed or underway

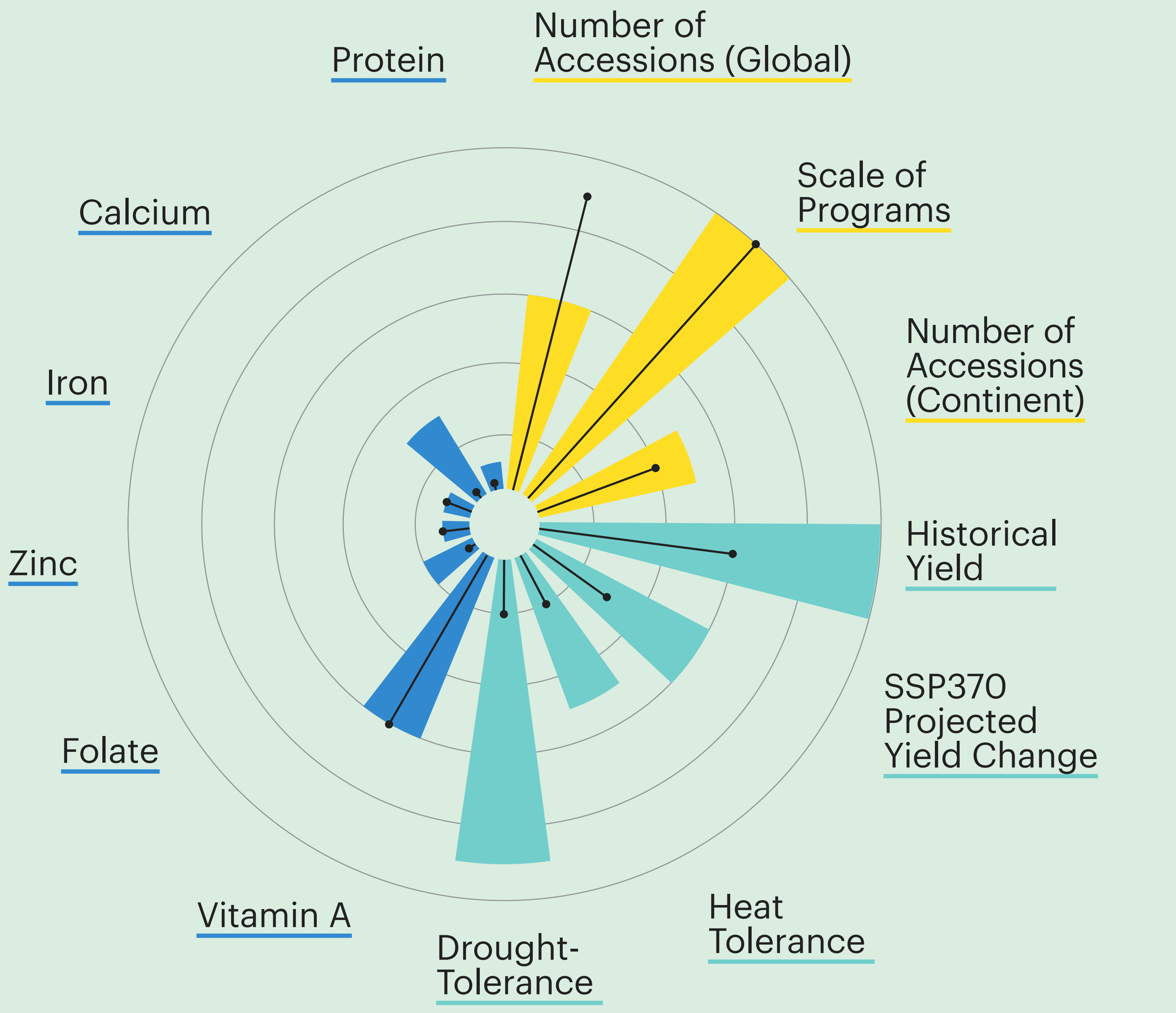
| | | |
|---|---|---|
| Biophysical | Economic | Sociocultural |
| Nutritional | Genetic | Environmental |

# Okra

## Climate Change Assessment

Okra has higher calcium, zinc and folate levels while iron and vitamin A levels are comparable to tomato. Okra has a moderate number of global accessions and a continent-wide degree of breeding programs. Its number of continent-wide accessions is higher than tomato but is still lower than average compared to other opportunity crops. Okra is very drought-tolerant and moderately heat-tolerant and is expected to increase overall projected yield across the continent from a high historical yield. Nonetheless, under both low and high emissions scenarios, there is a sharp decrease in yield in Egypt and a slight increase in yield change in Western Africa under both climate change scenarios, with slight decreases in the Western Sahel.

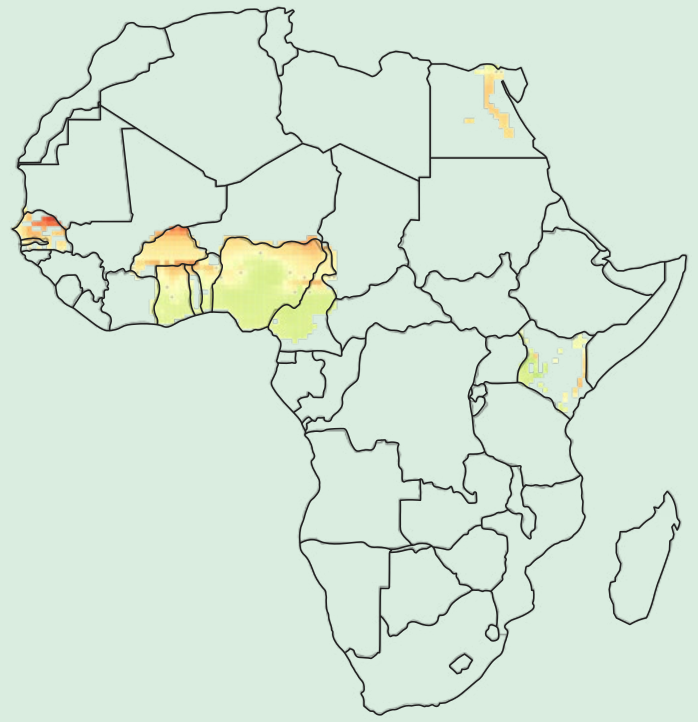
## Adaptation Indicators



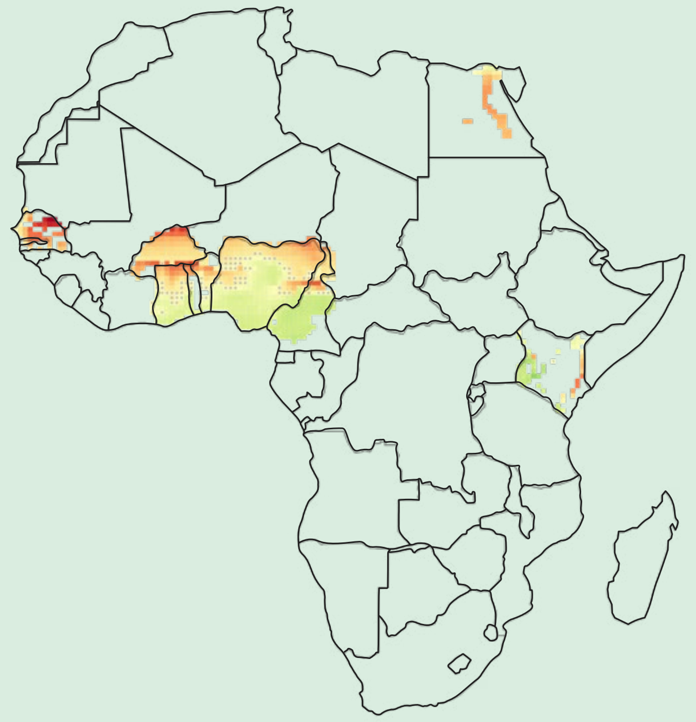

| | |
|---|---|
| Nutritional | Biophysical |
| Genetic | Reference/Comparator Crop |

## Yield Projections under Climate Change

**SSP1-2.6**
**Low Emissions**



**SSP3-7.0**
**High Emissions**



**% Change in Yield**

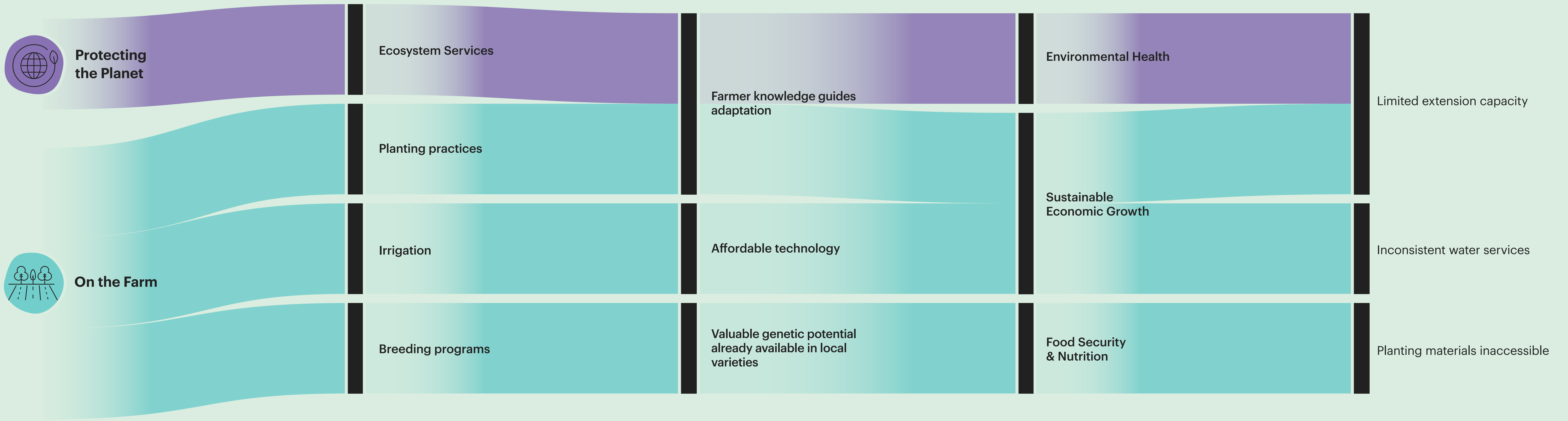
Model disagreement | 50 | 25 | 0 | -25 | -50

# **Okra** Intervention Pathways

Similar to African Eggplant, evidence for okra is limited. Crop management practices emphasize opportunities to improve irrigation and planting practices to minimize weeding in an effort to increase yield and productivity. Lack of post-harvest storage and processing opportunities in rural communities, including appropriate storage facilities, are noted as a barrier to scaling up okra.

| Biophysical | Economic | Sociocultural | Nutritional | Genetic | Environmental |
|---|---|---|---|---|---|

| Pathway | Interventions | Facilitators | Outcomes | Current Barriers |
|---|---|---|---|---|



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