Secondary Crops for Agricultural Diversification

Crop Suitability and Market Opportunities

The Rockefeller Foundation

Smallholder Data Services

Terra Genesis

Grant Number: 2022 FOD 018
Grantee: Smallholder Data Services
MARCH 2023

Foreword

Smallholder Data Services (SDS), supported by a grant from The Rockefeller Foundation, is working to ensure that smallholders who are directly involved in defining, implementing, verifying and scaling regenerative agriculture have a stakeholder voice as each of these aspects are being shaped at a global level.

In support of this goal, SDS and one of the founding partners of SDS, Terra Genesis, are generating a series of reports, recommendations, best practices and guidelines that draw from early-stage regenerative farming by smallholders in various parts of the world.

In this report, we present our analysis of the market viability and ecological viability of secondary crops as a driver of the transition to diversified regenerative agriculture systems among smallholder farmers.

In the course of undertaking the Rockefeller Foundation-supported initiative, SDS will be drawing on an additional founding partner: the Smallholder Farmers Alliance in Haiti.

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Smallholder Data Services

Smallholder Data Services (SDS) is a consulting and research firm exploring how big data and technology innovations are enabling a revolution in both sustainable supply chains and regenerative agriculture. We reimagine data as a new sustainability product that financially rewards farmers and others involved in sustainable production, including small-holders in the global south. We focus on how the combination of data products and emerging technology unlock solutions for those concerned with the environmental and social impact of the products and services they market and purchase.

More at
smallholderdataservices.com

Terra Genesis

Terra Genesis is an international regenerative design firm that convenes brands, farmers, developers, communities, investors, and NGOs to work at the intersection of agriculture, ecology and economy. Our work is to evolve the role of agriculture and business as drivers of social and ecological health. We work from the ground up to evolve stakeholder capacity and capability and to identify solutions, create processes and curate interventions for systemic regeneration.

More at
terra-genesis.com

smallholder farmers alliance

The Smallholder Farmers Alliance (SFA) is social business non-profit working to feed and reforest a renewed Haiti using a new agroforestry model in which smallholders plant trees to earn credits they exchange for seed, tools, training and other agricultural and community services. The SFA's 6,000 farmer members use organic methodologies, and are now in the process of transitioning to become regenerative.

More at
http://www.haitifarmers.org/

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Introduction

This report explores the market viability and agroecological suitability of secondary crops and specifically their ability to function as a catalyst for regenerative agriculture among smallholder farmers. The report focuses on four broadly defined geographic regions: the Caribbean, South America, Southeast Asia, and Sub-Saharan Africa.

Image: Marco Schmidt

The core question of this report is: *how can bringing secondary crops to market serve as a catalyst for the revitalization of land, communities, and local and national economies in these regions?*

The reason why this question is important is that species and crop diversification is often a key aspect to a more regenerative agriculture. Moreover, although the ecological benefits of species diversification are fairly well understood, not much research has been done to understand the potential of crop diversification as an opportunity to create more economic traction and resilience, and thereby better enabling the transition to regenerative agriculture.

First a brief clarification of the following key terms: *secondary crops, smallholder farmers, and regenerative agriculture.*

Secondary crops here refers to any crop other than a primary commodity crop in a farm system. In other words, it can refer to agricultural crops that usually are not included on lists of the world's top agricultural commodities; or it can refer to crops that do count as major commodities (e.g. cacao, coffee, cassava) but that are grown as a companion crop for other crops that the farmer in question considers equally or more significant.

Smallholder farmers are usually defined as farmers who farm on 2 hectares of land or less. There are however significant limitations to that definition. Hazell and Rahman address this issue and take Ecuador as an example: on average, a subsistence farm in the Coastal plains is twice as large as one in the Andean Highlands, while one in the Amazon Basin is eight times larger. At the same time, a farm of 4.5 hectares in the Andes is already 'transitioning to family farm commercial enterprise', while one of

25 hectares in the Amazon Basin is still in the 'subsistence' group. As the authors rightfully conclude: "Clearly, using farm size alone as a criterion will lead to wrong strategic and policy decisions." (Hazell and Rahman 2014) This report takes into account, where applicable, the above-mentioned need for a nuanced approach with regards to what constitutes smallholder farming.

For **regenerative agriculture,** we are working with the definition introduced in the first report in this series: Regenerative agriculture is a system of farming principles and practices that is rooted in indigenous and ancestral agroecological traditions, but also draws from decades of scientific and applied research by the global communities of organic farming, agroecology, holistic grazing, and agroforestry. It is farming in ways that replenish soil nutrients, help to clean waterways and air, capture carbon, and create multi-functional, multi-layered, biodiverse farming systems that function holistically and support the well-being of all forms of life within its fold and beyond. Regenerative agricultural systems include ecological, social and cultural systems, and as such they encompass the well-being of the farmers, their communities, and those they impact, as well as the landscapes they are a part of, the ecosystems in which they are nested, and the ecosystems they impact.

In researching pathways for market access and meaningful agricultural livelihoods for smallholder farmers, we have identified that for regenerative agriculture to effect transformative change on the ground, it must embrace the socio-political reality as well. Regenerative agriculture does not explicitly integrate political realities, in contrast with the agroecology movement, which has been more closely associated with peasant movements (even though the two approaches are otherwise quite complementary).

As Tittonell et al. note:

> **"agroecology is more closely associated with peasant movements, for whom claims on rights and access to natural resources are urgent [...], while regenerative agriculture is an approach increasingly—but not exclusively—also adopted by commercial, often large-scale farmers or external investors less concerned with natural resource access or food sovereignty issues."**
>
> (TITTONELL ET AL. 2022)

In this report, we work with an understanding of regenerative agriculture that comes closer to the agroecology approach in the sense that it centers the consideration of the social and political. We cannot meaningfully discuss pathways for scaling regenerative agriculture among smallholders if we do not consider issues such as land tenure regimes and power dynamics, whether domestic or international. The strategies we propose for scaling smallholder-centered regeneration are founded on the crucial points articulated by Tittonell et al.

> **"(i) that resilience is often achieved through organizational innovations and/or collective efforts [...] and (ii) that there are farmers who are not able to adopt, adapt or innovate due to resource insecurity or barriers to accessing them, legitimizing unjust situations."**
>
> (IBID.)

Image Credit: Michael Commons 2022,
Rubber Coffee Bees Pineapples Yai Chim

SMALLHOLDERS AND MARKETS

There are between 450 and 500 million smallholder farmers in the world, with a concentration in Asia and Africa. While highly diversified, small-scale, multi-cropping farming was characteristic of many traditional agroecological systems in our regions of focus, in just a few decades the global agricultural commodity markets have been radically transformed and diversity has given way to the predominance of monoculture cultivation. Economies of scale tend to dictate what crops are grown, bought and sold. More often than not, smallholder farmers end up making compromises between market access and the diverse cropping systems they know to be ecologically and culturally appropriate.

TYPES OF MARKET ACCESS

Just as this report highlights the importance of diversity in terms of crops, it also stresses the importance of *diversity in terms of types of market access*. Again, smallholder farmers' contexts vary to the extent that there is no generic approach for accessing markets. Some may only want to sell to local markets; others may prefer the model of contract farming; others again would like to sell to the nearest big city but lack transportation; while some innovators excel in growing lesser-known niche crops, but need support in finding appropriate markets.

Four types of markets for secondary crops are explored in this report:

- *Commodity export markets*
- *Markets for novelty/experimental crops*
- *Domestic/local markets*
- *Subsistence crops for food sovereignty and security*

We have put equal, or potentially even greater, emphasis on local markets and subsistence crops than on export crops because adequate, nutritious food for farmers themselves, and their health and vitality, must be the foundation of any agricultural or market system that calls itself 'regenerative'. Having said that, we recognize that export crops hold their own significance because they have the potential to function as catalysts for regeneration.

Often, a price premium is one of the most effective incentives to transition to regenerative land management practices. Local or even domestic markets may not be in a position to offer that price premium, but export markets could.

CHALLENGES FOR FARMERS' ACCESS TO MARKETS

- Weak bargaining power due to fragmentation and low production volumes
- Markets are fragmented, so prices are volatile and markets are risky (Thapa and Gaiha 2014)
- High-value agricultural commodities are often perishable and farmers lack storage and processing capacity
- High transaction costs and risks in production and marketing of commodities, due to poor financing, lacking infrastructure and low volume
- Poor access to affordable credit; many smallholders rely on personal or group savings to finance their activities
- Stringent food safety and quality standards, and a lack of capacity and capability to address those
- Lack of knowledge and capability to address export certifications and requirements
- General distrust of agencies and institutional support
- Agricultural policies tend to work in favor of large commercial enterprises and agribusiness
- General lack of access to enabling resources: seeds, fertilizer, knowledge, technical support, finance, logistics
- Lacking infrastructure in many of the regions with high concentrations of smallholder farmers

Image Credit: Heather Suggitt on Unsplash

- Limited R&D for developing climate resilience in locally relevant crops (Dessources, 2023).
- Disadvantaged position of women with regards to access to knowledge and resources
- A general lack of proficiency concerning finance and business in order to run a profitable and feasible enterprise

SPECIFIC BARRIERS FOR AGROFORESTRY CROPS

- Often times secondary crops from agroforestry systems have underdeveloped markets
- Agricultural policies tend to focus on conventional agricultural methods used in monocropping systems
- A lack of knowledge about agroforestry systems resulting in negative biases, the idea that 'perennials will compete with cash crops'

Image Credit: Fundecooperacion para el Desarrollo Sostenible

SMALLHOLDERS AS ENTREPRENEURS

One theme that has been pervasive throughout our research, as well as interviews with those that support and work with smallholders farmers, is the importance of cultivating smallholder entrepreneurship. (Rueda, 2023)(Struebi, 2023). For decades, smallholders have found themselves in a precarious situation at the bottom of an extractive global economy, marginalized by big agribusiness, or passive recipients of aid from NGO's. Many farmers live in a state of survival, sometimes with distrust toward their own farming communities; lack education and technical know-how; and have over generations become entrenched in the industrial monoculture operations they have been colonized by. (Rueda, 2023) Subsequently, many suffer from low self-esteem, poor health, a scarcity mindset, and are easily swayed by 'experts' serving corporate interests.

Instead of aid and external parties dictating to the farmers what they must do, a more successful approach is supporting farmers with acquiring the skills needed to run their farms as a farming business. These farmers develop the skills needed to run their farms effectively as enterprises. This shift sees farm profitability go up, quality of produce go up, and farmer self-esteem grow. Companies like Fairtrasa have had success collaborating with farmers by emphasizing entrepreneurial capacity building. Farmers treated as entrepreneurs cultivate a different mindset – one of engagement, inquiry, and confidence. These farmers are more likely to develop leadership skills and collaborate with others, enter into cooperative partnerships, and lift up their own and communities' well-being.

ENABLING ENVIRONMENTS

Smallholder farmers are not a homogeneous group. They vary widely in terms of their key crops, ecosystems, farming practices, degree of commercialization and market participation. For this reason, this report refrains from proposing a single model for facilitating market access for smallholder farmers. **The appropriate model depends on the context and the specifics of both local agroecology and local markets as well as the perspectives and aspirations of the farmer, and on-the-ground communities and organizations.** Based on such contextual understanding, it is possible to differentiate strategies and policies according to the specificity of smallholder farming communities and groups.

Instead of proposing a single model, this report and the accompanying Market Pathways Diagrams identify **enabling environments** that support equitable market access and the development of diversified production systems.

A focus on enabling environments allows for an assessment of the relationship to market in which farmers across different contexts find themselves, and simultaneously suggests possible trajectories for further evolution of their farm and farming context as well as the development of strategies to that end. *(See Market Pathways Diagrams in Part Two, p. 77)*

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Part 1:

Region-Specific Crops and Their Associated Market Opportunities and Risks
The Caribbean

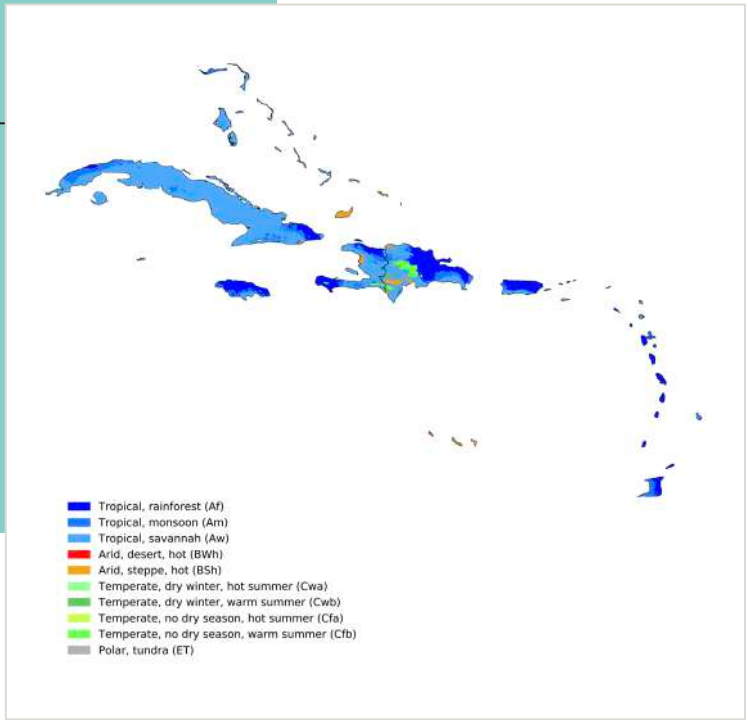


Image Credit: Beck et al. 2018, Köppen Climate Map of the Caribbean

CONTEXT

The Caribbean comprises 13 island-based sovereign states. These islands exist in tropical and subtropical climates, with certain countries like Haiti receiving significantly less rainfall than neighboring islands. Many of these countries are currently importing staple crops that are climatically suitable to be grown domestically. This is due largely to the challenges of competing with a global marketplace, where it is often cheaper for countries in the Caribbean to import crops than produce them on their own. While this may be economically favorable in the short term, it leaves island nations especially reliant on importation infrastructure and therefore vulnerable in terms of food security.

Regenerative agriculture in Haiti is currently limited to cotton being grown as an export crop by smallholders. Secondary crops are being grown primarily to ensure diversification as part of the regenerative system, but there is interest in learning more about local market opportunities for these crops as a way to show added financial benefits to smallholders.

EXPORT CROPS

The following crops are identified as beneficial export crops in the Caribbean:

- Banana
- Legumes *(cowpea, black bean, pigeon pea)*
- Breadfruit
- Cacao
- Cassava/Yuca
- Coconut
- Coffee
- Corn
- Cotton
- Ginger
- Moringa
- Plantain
- Rice
- Sorghum
- Sugarcane
- Orange
- Sweet potato
- Tobacco
- Yam
- Pimento

The Caribbean has long served as an exporter to the global market, supplying an abundance of tropical crops. Recently, though, countries in the Caribbean have struggled to participate in export markets, due to a variety of reasons listed below. Statistics from Jamaica demonstrate this trend: in the 1990s banana exports were valued at US $43 million, in 2020 they were valued at $725,000; in the 90s, sugar exports were worth $85-$101 million, and in 2020 they were priced at $7 million; cocoa export was $5 million in the 90s and $348,000 in 2020, and coffee exports were worth $28 million in the 90s, yet $16 million in 2020 (Morgan, 2021).

Market niches can play into the viability of promoting these exports. For example, rice grown in the Caribbean tends to struggle as a global export because of competition with the affordability of rice grown in other places. Rice that is grown organically may be produced and sold as a premium crop for global export (Dessources, 2023).

OPPORTUNITIES:

A focus on the development of better infrastructure will have a leveraged effect on export capabilities. Accessing export markets requires significant infrastructure, including aggregation and storage centers, processing facilities, trucks, and roads

Upfront funding for training and infrastructure can have a long-term impact on farmers' success in export markets. As an example, peanuts are susceptible to developing aflatoxin as a result of fungus developing in poor storage environments. Training and access to proper infrastructure has helped peanut farmers in the Caribbean to avoid aflatoxin, thus enabling them to access global markets with higher standards. In this case study, a market premium was not necessary, only market commitment. Upfront financing was needed for the trainings and infrastructure, but now market access alone provides financial stability for this project to see long-term success (Johnson, 2023)

Opportunities for export markets are more likely to succeed with the support of **a guaranteed market**. Cacao and cotton are two examples of crops recently reintroduced in the Caribbean as a result of a secured market and supporting partners

Particularly in Haiti, regarding the risk of gang violence (elaborated on in risks below), one interviewee had a hopeful outlook, which is to consider that gang members are usually community members that resort to violence in order to meet their basic needs. **Creating opportunities in agriculture by developing better market access, might play a role in increasing local food security, and local employment opportunities, addressing some of the lead causes for organized crime and violence.** Ultimately, it is important to listen to local leaders, to understand what opportunities exist locally. (Georges, 2023)

RISKS:

- One primary risk of export markets is that **farmers typically receive a significantly smaller percentage of the final sale of the product in export markets.** As such, as many middlemen as possible should be removed, and aggregation should take place at a cooperative level where producers are active beneficiaries of the aggregation process

- In addition, a risk of promoting export markets is that **smallholders may struggle to meet the notably high product standards required by export markets.** In order to support farmers in meeting market standards, programs must also include trainings to assist farmers in learning the best methods for harvesting, storage, and preliminary processing (Georges, 2023)

- Another risk of introducing additional export crops to a community is the **likelihood of gang violence arriving** to the community. Gangs may begin to notice an increase in truck traffic and get involved due to the higher volumes of money exchanged. For example, in the Central Caribbean, farmers grow and sell coffee to local markets only, despite it being a profitable export crop, because they could not safely deliver the green coffee beans to the port for export. (Dessources, 2023) Importantly, gang presence may result in violence, which will put producers and other partners in danger. When this happens, farmers may choose to bail on the industry and transition to other crops they are less familiar with (and those that may be less culturally relevant). Interviewees felt that gang presence may be unavoidable. One interviewee felt that government intervention would be necessary in order to suppress gang violence

- **Without proper storage infrastructure, post-harvest loss of export crops is typically very high**

- **Some export crops may require land at a prohibitively large scale for smallholders to participate.** For example, sorghum was introduced to the Caribbean unsuccessfully. On paper, sorghum introduction made sense (it is a valuable rotation crop, is suitable for the climate, and has an established marketplace). But smallholders growing it at a small scale struggled to dedicate hectares to the crop when more profitable crops could be grown instead. Raising limes may yield $3,000-4,000 and peanuts $800 as compared to sorghum at $100 on similar acreage (Johnson, 2022)

- **Small island nations struggle to cultivate healthy food systems, in part because they export too much of their high-quality food crops.** Promoting export markets without sensitivity to local food needs may result in the exacerbation of its prevalence, and lead to negative effects for food security. (Marrero and Mattei, 2022)

EXPERIMENTAL CROPS

Experimental crops for the Caribbean region include:

- Acai
- Castor Bean
- Cotton*
- Fonio
- Moringa
- Pumpkin/Squash

Few experimental crops arose for the Caribbean, primarily because of local hesitation to put greater emphasis on export markets at the expense of local markets. That said, there are a few key crops that may provide value to farmers' cropping systems while also providing a profit.

** Despite having an established global marketplace, cotton's history in the Caribbean warrants its inclusion here. The presence of cotton in the Caribbean was historically tied to the use of slave labor. At one point, cotton was Haiti's fourth largest agricultural export until it disappeared in the late 1980s (Locke and Georges, 2022). Now, in nations such as Haiti, cotton is reemerging. This reemergence places cotton here as "experimental" due to the fact that the market has not been tested in some time.*

OPPORTUNITIES:

- Some experimental crops are **often lesser known in the market,** meaning that markets may be less competitive and direct relationships with purchasers may be more feasible.* Demand for these crops is likely to increase over time as they become more familiar in the marketplace

RISKS:

- In many instances, **markets for these crops are less established.** Farmers may risk market instability without a committed buyer

Image Credit: kellymlacy on Pexels.com

LOCAL AND DOMESTIC MARKET CROPS

Crops for these markets include:

- Banana
- Black (Turtle) bean
- Cowpea
- Breadfruit
- Cassava/Yuca
- Chili hot pepper
- Coffee
- Corn
- Ginger
- Melon
- Peanut
- Pigeon pea
- Pimento
- Plantains
- Pumpkin/squash
- Sweet potato
- Yam
- Yautia

Interviews with experts in the region affirmed that the Caribbean has a notable need to focus on establishing and strengthening local and domestic markets (IICA, 2021). This is because the region has a history of importing staple crops and other culturally relevant crops that can otherwise be grown domestically. As of 2011, imports accounted for an average of 80% of total food consumption in the Caribbean, with some nations such as the Bahamas and Antigua and Barbuda importing up to 92% of all food consumed (Wuddivira et. al. 2017). A reliance on imports marks an underdeveloped domestic food economy, and:

> **"the destabilisation of local food sectors undermines small island social and cultural systems, contributes to impoverishment and food insecurity during natural disasters, and, ultimately, can reduce diet quality and increase type 2 diabetes risk"**
>
> (MARRERO AND MATTEI, 2022).

PLANTAINS

Focusing on local markets is necessary and often underlooked by external funders and project developers (Johnson, 2023). While the Caribbean is composed of mainland and island nations with notably different cultures and economies, the region has identified a desire to promote interregional trade and leave behind a historic reliance on imports from other regions of the world (IICA, 2021). Thus, a transition away from reliance on external food sources towards a more internal source of food can be thought of on three levels:

- **Local:** community-level markets, or those that farmers themselves may travel to, to sell and buy at
- **Domestic:** markets within a country
- **Intraregional:** trade within a region (in this case, the Caribbean) that includes importing and exporting across national borders. International trade that takes place intra-nationally can promote culturally relevant diets and a strengthened food security and food sovereignty (IICA, 2021; Marrero and Mattei, 2022).

For a region that has notably high tourism, promoting the buying and selling of crops from these three markets can bring in external tourism-based revenue, thus strengthening the local food economy (IICA, 2021) (Wells Russell, 2021).

OPPORTUNITIES:

- Fewer intermediaries are needed to access local markets, meaning **farmers typically receive a higher percentage of the final sale price** (Georges, 2023)

- It may be difficult for farmers to export perishables. Therefore, local markets are **best positioned for farmers to sell perishables,** thus enabling farmers to diversify their harvests. Perishable foods are also more expensive to import, so local markets of perishable crops will not have to compete with imports as often

- **Local markets provide weekly/biweekly income for producers,** as opposed to export crops which are more often only harvested and sold once or twice a year (Dessources, 2023)

- Post-harvest loss in the Caribbean is fairly high due to a lack of transportation and storage. **Local, domestic, and some intraregional markets can receive crops more quickly,** thus helping to prevent this

- Farmers are often not equipped to bring excess crops home at the conclusion of a market day. **If local markets, such as grocery stores, are equipped with cold storage, they may be able to keep farmers' excess produce to sell at a later date.** This would increase farmer profits and improve local food access (Dessources, 2023)

- Farmers need to be paid in a timely manner, and selling directly to a buyer through **local market pathways may provide quicker payment than export markets do**

- Local, domestic, and intraregional markets typically struggle to compete with US imports due to proximity. The US has the largest market share of crops imported into the Caribbean; as of 2020, about 50% of all agricultural products in the Caribbean are supplied by the US (Wells Russell, 2021). As a result, it may be strategic to **focus on the sale of crops that cannot be grown in the US, such as coffee and cacao**

- **"Local food production — bolstered by local and Indigenous agroecological knowledge, cultural preservation, and collective agency — can aid in reclaiming healthy and climate-resilient small island food systems"** (Marrero and Mattei, 2022)

- Because tourism contributes significantly to the economy, local market buyers also include **the hospitality industry, including resorts, hotels, and restaurants** (Wells Russell, 2021)

- Local markets provide farmers with the opportunity to **test production methods and develop production capacity** before reaching commercial export markets (Georges, 2023)

RISKS:

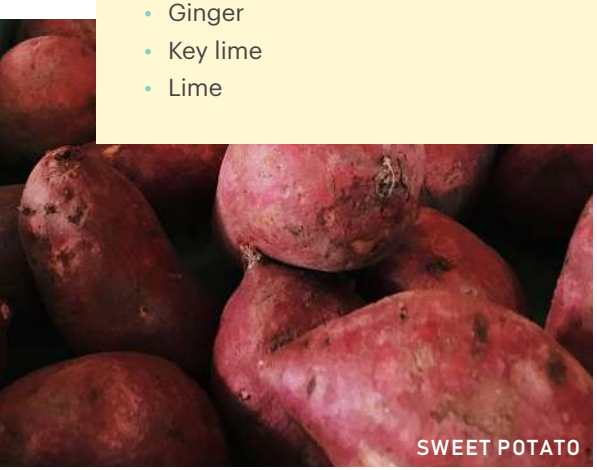
- In many cases, **crops in local and domestic markets simply cannot compete with the affordability of crops sold through the global marketplace** (Dessources, 2023). Rice, for example, is a staple crop that can be grown in the Caribbean. Yet, locally produced rice is considered a luxury since it is considerably more expensive than rice grown overseas. In some instances, import tariffs may support the competitiveness of local crops, but increasing the expense of imports may only exacerbate the food-access challenges that many in the Caribbean face. **Subsidies may be an alternative way to support local food production, but subsidies require long-term funding, which may not be available** (Wuddivira et. al. 2017)

- Certain places, such as Haiti, have **limited access to grocery stores and centers with refrigeration.** This is notably prohibitive for the success of local markets (Georges, 2023)

SUBSISTENCE CROPS

The following crops are popular traditional subsistence crops in the Caribbean:

- Avocado
- Banana
- Black Bean (Turtle)
- Cowpea (black eyed pea)
- Jack-bean
- Common bean
- Breadfruit
- Cacao
- Cassava/Yuca
- Coconut
- Coffee
- Corn
- Ginger
- Key lime
- Lime
- Mango
- Melon
- Papaya
- Pigeon Pea
- Pimento
- Pineapple
- Plantains
- Pumpkin/ squash
- Sweet orange
- Sweet potato
- Taro
- Yam
- Yautia



SWEET POTATO

Island nations of the Caribbean have a history of nutrient-rich subsistence diets including seasonal fruits, legumes, nuts, seeds, and endemic root species. Evidence suggests a strong indigenous reliance on starchy plants, including cassava, yautia, and maize. This heritage of subsistence based on diverse cropping systems has informed current dietary preferences. Supporting food sovereignty through the production of locally relevant cropping systems helps to promote food security, diet quality, and cultural reemergence (Marrero and Mattei, 2022).

Forest gardens are one of the oldest forms of agroforestry in the world and were common among Caribbean communities as a form of subsistence (Morgan and Zimmerman, 2014). In a study on diversified multi-strata garden systems in Haiti, researchers noted a linkage between land tenure and the diversification and resilience of these systems (Jean-Denis et. al. 2014). Diversification takes multiple years, and planning out a complex cropping system is facilitated by a long-term relationship with a plot of land.

OPPORTUNITIES:

- Perishable foods are often expensive to import. Therefore, in addition to local markets, **farmers may increase food security by growing their own perishable crops** (Johnson, 2023)

- When farmers grow crops for the export market, they may only get paid once or twice a year. This inconsistent income may threaten food security. **Growing subsistence crops may help farmers access food even when incomes are unreliable**

- Focusing on subsistence crops may also increase food sovereignty. When farmers rely on markets, they only have access to what markets have made available to them. By growing subsistence crops, farmers have more agency to grow crops that are culturally relevant and preferable within their household

- In the Caribbean, market infrastructure is particularly limited for many communities. **Growing subsistence crops may increase the resilience of communities to global disturbances and market instability**

RISKS:

- Dedicating land for subsistence may feel intimidating to producers, as it may mean **reducing the amount of land they have dedicated to producing a profit**

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Region-Specific Crops and Their Associated Market Opportunities and Risks
South America

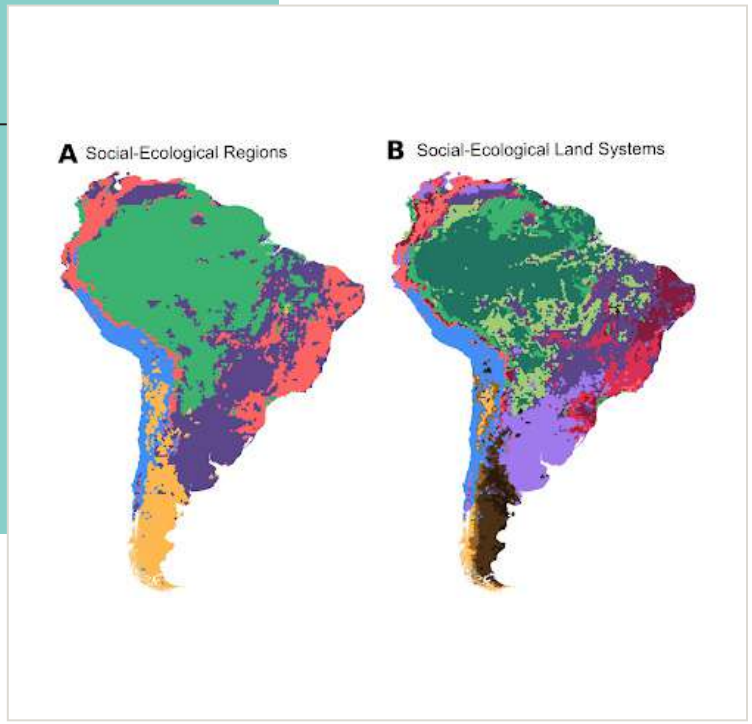


Image Credit: Zarba et al. 2022

CONTEXT

The South American continent is vast and hosts a variety of geographies and climate types. These landscapes are home to an enormous biodiversity nested in various hotspots like the Tumbes-Choco-Magdalena, the Tropical Andes, the Atlantic Forests, the Cerrado, and Valdivian Forests. There is a marked correspondence among areas with high biodiversity (hotspots) and territories of peasant and indigenous communities and shows that biological and cultural diversity are reciprocally dependent and geographically coexisting. (Rendón-Sandoval et al., 2021) It also creates tension between the health of the ecosystem and agricultural productivity.

Agriculture in South America covers a diverse range of different socio-ecological and agro-ecological zones with different sizes of farming operations that operate at different levels of technological sophistication. Significant parts of the population depend on the sector for their livelihoods. Recent estimates state that 14.1% of the total labor force in the LAC region was employed in agriculture. Countries such as Bolivia, Ecuador, and Peru employed more than a quarter of their labor force in the agricultural sector (OECD-FAO, 2019).

Recent decades have seen increasing pressures connected to instability, be it climate change, supply chain disruption, or political turmoil; all of which have impacted smallholders. Consequently, smallholder farming, and agriculture in general is undergoing major shifts in response to increased ecological, social, and economic volatility.

Regenerative agriculture in South America is part of that shift, and the movement is growing. The emphasis has largely been on coffee and cacao growing operations, in most cases intercropped with banana and plantain. A continued evolution of this development would see diversification into other interesting marketable crops, as such there is much interest to explore the viability of secondary crops, and understand better where the potential lies and how it can be explored.

General patterns affecting agricultural markets in the region

PERSISTENT ECONOMIC INEQUALITY

Inequality is in large part the reason why economic growth and, indeed, the rapid transformation of Latin American societies, have not resulted in a more substantial poverty reduction. (Hazell and Rahman, 2014) There is still a high incidence of poverty (48.6%) and extreme poverty (22.5%) across South America in rural areas particularly. Since 2015, the poverty gap has widened when looking at factors such as access to basic public services. In addition, the number of undernourished people has been increasing over the past decade which – according to the FAO – is a problem related to the affordability of food by impoverished consumers, rather than the actual availability of food. (OECD-FAO, 2019)

A STRATIFIED SMALLHOLDER / FAMILY FARM SECTOR

The existing socio-economic inequality has a corollary in the organization of the agricultural sector. The OECD-FAO report on 'Prospects and Challenges in Latin American Agriculture 2019-2028', identifies three main divisions in the region's agricultural sector:

- A capital and technology intensive corporate sector that has successfully managed to integrate itself into global agrifood markets
- A broad socio-productive sector based on subsistence farming, non-farming rural activities and landless rural populations that have been unable to participate in dynamic economic circuits
- An intermediate sector that is able to connect to markets, but that continues to be extremely vulnerable to economic and political shocks as well as to climatic risks

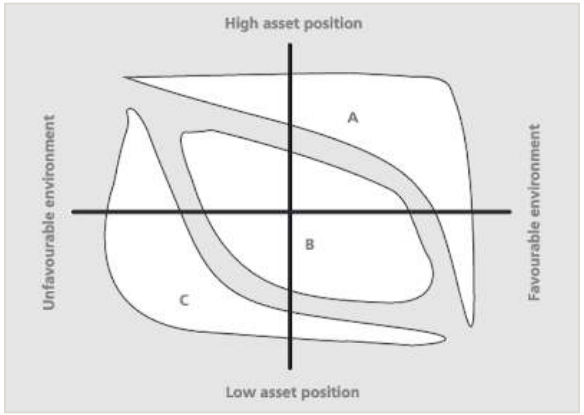
(OECD-FAO 2019)

These three strata of farmers' operations – approached through the lens of smallholder and family farming – can be understood in terms of two principal factors that determine successful outcomes.

- Access to farming assets
- Favorability of the environment in relation to agricultural productivity

Image Credit: Dado Galdieri / Hilaea Media, 2022

The smallholder - family farming groups can then be characterized as following:



Types of family farms according to asset endowment and context by Berdegué and Escobar | Image Credit: Hazell and Rahman (2014)

- **A.** Asset-rich smallholders in territorial and regional contexts that are very conducive to economic growth and social development.
- **B.** Smallholder agriculture with some limitations of assets in territorial and regional contexts where there is a measure of economic growth and social development.
- **C.** Asset-poor smallholders in territorial and regional contexts that are not conducive to economic growth and social development.

In summary, taking the words of Hazell and Rahman:

> **'the state of family farmers in [South America] as a diverse social group is [one that is] caught between these two realities: a rapidly changing context that creates new incentives and new opportunities, and the dead weight of structural inequalities that constrain many from participating in and taking advantage of development processes.'**

(HAZELL AND RAHMAN, 2014)

It is necessary to differentiate strategies and policies according to the three categories of smallholder / family farms. Greater attention needs to be paid to domestic food markets, with an emphasis on commodities (see section on local and domestic market crops). Also, it is necessary to emphasize the development of public services and public goods that can work at the scale of 15 million family farms, in contrast with programs that have given greater priority to transferring private assets to, inevitably, only a small proportion of family farmers. (Hazell and Rahman, 2014)

PUBLIC-PRIVATE PARTNERSHIPS

A variety of public-private partnerships over the last decades, alongside progressive agriculture policy, has led to leaps in increased capacity and capability across the whole South American/ Latin American agricultural sector, ranging from government collaborations with research institutions, smallholder NGO advocate groups, technical service providers, and so on. The report on prospects and challenges in Latin America by the OECD-FAO states that government agricultural research institutions, sometimes working together with the private sector, have played a key role in operationalizing government expenditure in R&D to increase productivity. For instance, Brazil's EMBRAPA, the largest agricultural research institution in the region, completely transformed agriculture in the Cerrado region (savanna area) in Midwest Brazil by introducing technologies from abroad (nitrogen fixation, no-tillage practices, for example) and livestock breeds, and adapting them to the local conditions to produce cotton, soybeans, maize and cattle.

The same report goes on to state that parallel investments in agriculture's enabling environment can leverage the benefits of research and development, complementary factors include policies that improve economic incentives for producers, stronger rural education and agricultural extension services, and rural infrastructure that improves access to markets. (OECD-FAO 2019)

CLIMATE CHANGE AND NATURAL DISASTERS

Many parts of South America are vulnerable to natural disasters such as volcanic eruptions, floods, droughts, earthquakes, hurricanes, and in general climate change. It is reported that the LAC region is the second most disaster prone region in the world affecting approximately 152 million people in the past two decades have suffered the adverse consequences of natural disaster.

- Floods are the most common disaster in the region
- Brazil ranks among the top 15 countries in the world with the greatest population exposed to river flood risk
- An average of 17 hurricanes per year and 23 Category 5 hurricanes (2000-2019)
- 25 percent of earthquakes magnitude 8.0 or higher have occurred in South America
- Drought is the disaster which affects the highest number of people in the region

(OCHA, 2020)

Floods in Brazil February 2023
Image Credit: Tribuna do Povo/Reuters

Drought in Rio Grande Sul Area in 2022
Image Credit: Reuters

Droughts and floods are regularly making the headlines all across South America. Already the effects of climate extremes and the increasing irregularity of weather patterns is having a significant impact on smallholder farmers and their capacity to produce. A likely consequence of the changes in precipitation and temperature extremes in prone areas is going to be a general shift from subtropical to tropical conditions, and from tropical monsoon to savanna and semi-arid conditions.

This is where crop diversification and planting resilient and hardy species will play an important role to weather the possible changes in climate ahead. To that end it is important that farmers become educated about the strategies they can employ to face the extremes of climate, including better understanding their context and development of appropriate diversified agro-ecological systems.

FOOD SECURITY

The past decade has seen a steady rise in food insecurity in Ecuador, doubling from 6% in 2015 to 12.8% in 2020. (FAOSTAT, 2021) This number is representative for many parts of South America, especially those with large rural populations.

Moreover, a significant portion of the population lacks proper nutrition. In 2015, 10.9% of the population suffered from malnutrition, although this was significantly less than the 19.4% reported in 1991. In 2012, 6.4% of children under 5 were underweight, slightly above the 6.2% reported in 2004 (FAO, 2017). In the past decade there has been no improvement. More recent numbers show that Ecuador currently has the second highest rate of chronic child malnutrition in Latin America, after Guatemala. According to the United Nations Children's Fund, one in three Ecuadorian children suffers from malnutrition. Of those, 40.7% are Indigenous. In just over a fifth of the malnutrition cases, learning is affected. (AP, 2022)

Iron deficiency is the most prevalent problem of micronutrients in Ecuador, affecting more than 50% of the population in most age groups, together with moderate levels of vitamin A and zinc deficiencies (FAO, 2010). However, the indigenous population is disproportionately affected. For example, 42% of indigenous children under the age of five suffer from stunted growth. (Aguirre et al. 2017) Ecuador's story is an echo of the fate that many at the lower socioeconomic echelons suffer in South America, where the specificity of the context may differ, but the structural problems are often the same.

Food insecurity impacts infant health, especially in indigenous communities Image Credit: AP

CROP RESEARCH

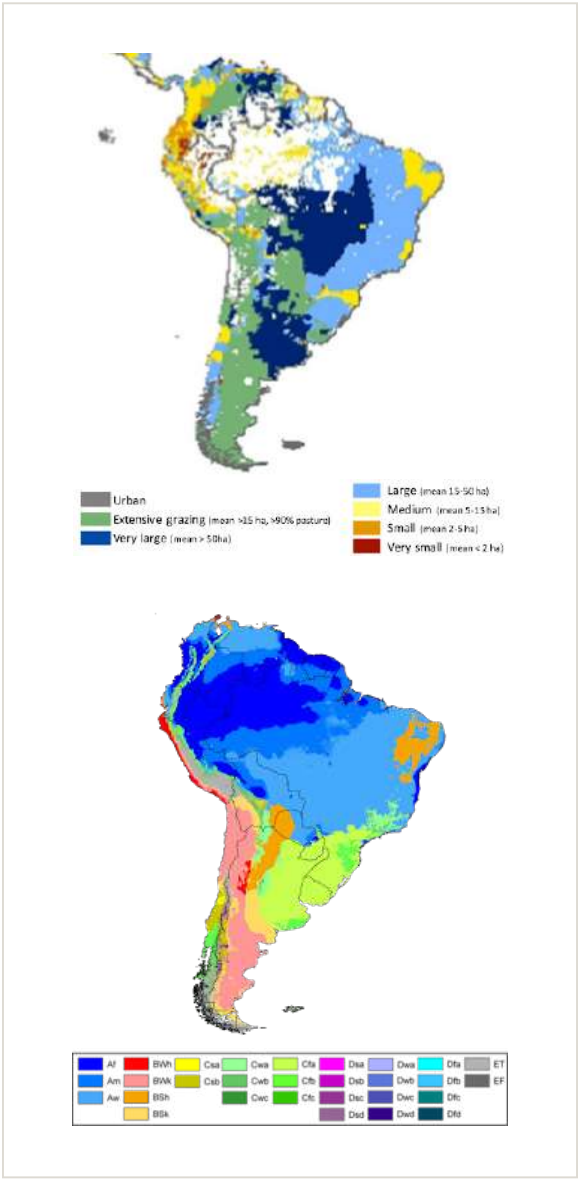
What follows is a selection of recommended secondary crops that have potential to add value across three different scales of economic realities, these are: subsistence crops, local/domestic market crops, and export commodity crops.
A fourth category that works across these three scales is experimental crops.

South America as mentioned before is incredibly diverse, for practical purposes the scope of crop exploration was narrowed down to those crops and markets most relevant to smallholder farming. Some aspects of the research lean more strongly toward smallholder farming in Ecuador than others since it formed the point of departure for the crop research. However on the whole crops are drawn from all relevant socio-ecological land systems across South America. (Zarba et al. 2022)

The main consideration was a focus on the prevalence of smallholder farming across the continent, to find the right geographical and climatic focus. This yielded a concentration of smallholder farming within the Tropical range, across the **western Pacific coast** to **Andean Highlands,** sloping down to the **Amazon basin,** and across to the **Brazilian Caatinga**. Overlaying a climate type map then results in a focus on four Köppen climate types:

- **Temperate Climate**
  (Andean Highlands)
- **Humid Tropical Climate**
  (Amazon Basin)
- **Tropical Savanna Climate**
  (Ecuadorian Coastal Pacific, Caribbean Coast, Brazilian Atlantic, and Cerrado)
- **Arid Steppe Climate**
  (Brazilian Caatinga)

The Southern Cone of the continent was omitted due to low concentrations of smallholder farming, and a fundamental difference in the nature of farming practices. It must be noted that many of the species mentioned can be applied to the Central American and Caribbean context as well.



Concentration of Smallholders and Köppen Climate Types
Image Credit: Samsberg et al. 2016,(Top) Beck et al. 2018 (Bottom)

SOUTH AMERICA IN THE GLOBAL ECONOMY

The region has positioned itself as a leading exporter of agricultural products. Latin American countries are major exporters of soybeans, pork, maize, poultry, animal feed, sugar, coffee, and fruits and vegetables. Brazil is the largest agricultural and food exporter in the region, followed by Argentina, Chile, Ecuador, and Peru. Major export crops from South America include: coffee, cacao, banana, cotton, palm oil, sugarcane, oranges, pineapple, cassava, maize, soy beans, wheat, and barley. Overall, South American agricultural trade surpluses have steadily increased over the past two decades, reaching USD 104.3 billion in 2017. (OECD-FAO, 2019)

MERCOSUR

An important aspect of what characterizes economics around agricultural commodities in South America is the MERCOSUR free trade bloc, also known as the Southern Common Market. This free trade association is composed of the full members Argentina, Brazil, Paraguay, and Uruguay, and associate countries Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, and Suriname. The aim is to promote free trade and the unobstructed movement of goods. It is currently characterized and directed by a common trade policy amongst its member countries. As of 2022, MERCOSUR counts as the sixth largest economy in the world, and has free trade agreements with the European Union and Japan, amongst other countries and trade coalitions.

BABASSU

COMMODITY EXPORT CROP LIST

The following list is a mix of annual and perennial crops. There are short and long cycle crops. Crops from a range of forest strata, such as herbaceous, shrubs, small and large trees, emergent canopy trees, as well as vines. The main consideration is that the crops listed be part of diversified production systems, where they exist alongside a primary production crop. In addition, the list considers major commodity crops currently being produced in countries like Peru, Columbia, and Brazil, as proof of market demand. This informs the potential for smaller countries like Ecuador in terms of crop market feasibility.

Main market categories are tropical fruits, dried fruits and nuts, spices, and vegetable oils. All these categories have on-going export demand and growing markets. In particular, there is an opportunity for palm oils and other vegetable oils to be produced in a sustainable and regenerative manner, as there is a strong growing demand from the market: 'sustainability concerns influence the expansion of palm oil output as demand in developed countries favors oils not associated with deforestation and seeks sustainability certifications for vegetable oil used as biodiesel feedstock and, increasingly, for vegetable oils entering the food chain.' (OECD-FAO, 2019) The global market outlook analyzed by the OECD and FAO states that global demand for vegetable oil will expand by +28 Mt by 2028 (OECD-FAO, 2019)

EXPORT CROPS LIST

- **Avocado** *(Persea americana)* Grown for fruit and for seed oil. High in lipids. Popular commodity export crop
- **Banana/Plantain** *(Musa spp)* Ecuador's main export. Integrates well in agroforestry systems
- **Black pepper** *(Piper nigrum)* High commercial value vining plant. Grows well in agroforestry systems on support species like Inga edulis or Gliricidia sepium
- **Brazil nut** *(Bertholletia excelsa)* Nut species with high commercial value, grows in the Amazon, high in macros and trace minerals. Threatened by deforestation, difficult to cultivate due to pollinator - orchid dependency. Conservation - production
- **Cacao** *(Theobroma cacao)* Ubiquitous export commodity. Hardy small tree, exhibits resilient in the face of climate stressors
- **Cashew** *(Anacardium occidentale)* A good option for dryland climates. As well as the nut and fruit, the plant has several other uses. The shell of the cashew seed yields derivatives that can be used in many applications including lubricants, waterproofing, paints
- **Chia** *(Salvia hispanica)* Superfood seed grown at altitude in tropical highlands
- **Coconut** *(Cocos nucifera)* Grown for fruit, juice, and oil. Emergent palm species thrives in humid tropical climates. Good value commodity crop

- **Coffee** *(Coffea arabica/robusta)* Ubiquitous export commodity. Suitable conditions increasingly threatened by climate volatility events. Domestic research and development has potential to add value to commercialization in places like Ecuador
- **Cotton** *(Gossypium barbadense)* High quality species of cotton with a niche market, native to the Americas
- **Mahogany** *(Swietenia macrophylla)* Popular fast growing hardwood timber. Grown as overstory or border in mixed agroforestry production systems. Sustainable production in scarce and needed to counter bad land use practices / deforestation
- **Mango** *(Mangifera indica)* Climate resilient export commodity fruit. Thick skin and delayed ripening conducive to transportation
- **Oil palm** *(Elaeis guineensis)* The main vegetable oil producing palm. Controversial for its destruction of forests and habitat, a regenerative approach would set a strong alternative example
- **Orange** *(Citrus x sinensis)* Oranges grow well in the South American tropical climates. Store well and have a consistent market demand
- **Peanut** *(Arachis hypogaea)* Ubiquitous ground nut grows well in drier climates like tropical savanna and semi-arid regions like the Caatinga. Yields a nutritious nut high in protein and oil, has a consistently growing global market demand
- **Quinoa** *(Chenopodium quinoa)* Andean Highland crop, controversial for its negative impact on food security and food sovereignty, particularly in Bolivia. A regenerative approach, particularly from the above mentioned angle could set a strong precedent
- **Rubber** *(Hevea brasiliensis)* Global demand for regenerative rubber is gaining traction, especially regenerative rubber production in South America would set a precedent for sustainable production in the face of bad land use practices
- **Turmeric** *(Curcuma longa)* Ubiquitous root crop suited to most tropical climates with a strong export demand – 16% CAGR annual growth. Lends itself well to fill 'lost' spaces in the understory of agroforestry systems
- **Vanilla** *(Vanilla planifolia)* High value spice with consistent demand and volatile supply side, which creates opportunities for South American producers

OPPORTUNITIES:

- South America has an incredibly rich resource base, with a wealth of agricultural ecoregions where a broad range of crops can be grown

- Ecuador has the opportunity to expand its markets to European and Asian countries. Increased efficiency and infrastructure that accommodate quality standards would substantially support that development

- With targeted improvements in enabling market environments, a much wider range of smallholder farmers could connect with commodity export markets, making a significant impact on their livelihoods

- Within the context of regenerative agriculture, a commodity export crop could work as the core catalyzing agent for the overall financial sustainability of a smallholder farm enterprise

RISKS:

- Continued bad land use and management practices will erode the ability to produce commodity export crops

- Expansion of existing export production systems is wreaking havoc on natural ecosystems

- Climate risks are imminent and farmers need to cultivate the know-how to establish resilient agro-ecological systems that can weather climate extremes

- (Rural) Infrastructure is currently not developed enough to accommodate the demands of commodity export crops

- (Rural) capability and capacity is currently lacking to be able to aggregate supply and meet the requirements of many international commodity markets

- In addition to climate volatility, production systems must be resilient enough to withstand market volatility as well, which again implies an adaptive and diversified agro-ecological operation

EXPERIMENTAL CROPS

Experimental crops in the South American context are crops that might not have an established market share, either domestically or internationally, however have the potential to add value to those markets. Crops were selected considering the climate types and market opportunities in Ecuador, and by extension the northern part of South America, including Brazil.

In terms of experimental crops, South America in particular in recent decades has been a continuous source of novel foods. Some popular examples of this are moringa, açai, and acerola. Even crops like quinoa that are ubiquitous in the West were not known outside the Andes until the 1970s. As research about the properties of crops advances, so does market interest. A category that has done well is superfoods. There is however much more potential for the development of markets for novel crop species; a few areas with high potential are: food security (kaniwa), sustainable timber production (bolaina), fiber production (fique), and oil production (babassu palm). Some crops included like açai already have established international markets, however, they have not been developed as much in Ecuador or other countries outside Brazil. Other crops like fique have negligible existing markets, however they draw on a rich cultural history and have potential as domestic, regional, or international commodity crops.

Cacay or Wachanso promising crop for high quality oil Image Credit: CPC273, Creative Commons License

EXPERIMENTAL CROPS LIST

- **Açai** *(Euterpe oleracea)* Established growing market for superfoods. According to market studies the total açai berry revenue is expected to grow at 11.5% through 2022 to 2029. The global demand for its fruit has witnessed a steep increase. The species is native to Brazil, Ecuador, Colombia, Trinidad, Tobago, and Venezuela

- **Peach palm** *(Bactris gasipaes)* Fast growing palm, known as tropical subsistence crop. Recently explored for commercial use: 'Alliances between public organizations and private enterprises are needed to realize the potential for processing novel products from peach palm, especially in the pharmaceutical and cosmetic sectors'

- **Macauba palm** *(Acrocomia aculeata)* Macauba palm has a high potential for oil production and for diversification of co-products with some potential of value aggregation. Such a perennial and sustainable species will probably fulfill the requirements to become an important new commercial oilseed crop

- **Fique** *(Furcraea andina)* Nitrogen-fixing perennial fiber plant native to Andes. Cultivated mostly in Colombia, with many uses mainly used to make rope, cord, sacks, clothes, etc. Has much domestic and international potential as a strong natural fiber: 'At the global level, there is a deficit of jute and sisal fiber with characteristics similar to fique fibers, which become an opportunity for growth and competitiveness in the fique sector.'

- **Jackfruit** *(Artocarpus heterophyllus)* Jackfruit has a mild taste and meat-like texture that lends itself to being called 'vegetable meat'. For that reason, in the West jackfruit has become a very popular meat substitute with much export market potential. Jackfruit is a shade crop and can be intergrown with other crops to provide shade and create a regenerative ecosystem, which means there are opportunities for farmers to grow secondary crops that will not only increase their revenues but also enrich the soil by replacing nutrients

- **Cupuaçu** *(Theobroma grandiflora)* Cousin of cacao with similar properties and grown in similar conditions. Grows well in infertile soils, which aids in the regeneration of over cultivated land, mainly in the Amazon lowlands. At the same time it produces fruit and a nut butter that has commercial value mainly in the Latin American region


FIQUE

Image Credit: zuahaza.com

- **Guayusa** *(Ilex guayusa)* Present in evergreen or deciduous premontane forests of the Amazon, especially in the Ecuadorian provinces of Napo and Pastaza. The leaves of the guayusa tree are harvested fresh and brewed like a tea for their stimulative effects

- **Cacay/Wachanso** *(Caryodendron orinocense)* indigenous to the drainage basins of the Orinoco and Amazon rivers. Cacay is notable for the high quality oil extracted from its nuts, which is edible and is also used in cosmetics where it has promising commodity crop potential

LUCUMA

- **Lucuma** *(Pouteria lucuma)* The 'gold of the Incas' is native to the Andean valleys of Bolivia, Chile, Ecuador, and Peru, at temperate elevations of 2,700–3,000 m. It is used as a sweetener and sugar substitute. According to Maximize Market Research, the global lucuma fruit-sugar market is expected to grow at a rate of 4.32% per year, and is forecast to reach nearly US$ 1.45 Bn in market size by 2027

- **Sacha Inchi** *(Plukenetia volubilis)* Novelty cash crop from the Amazon Rainforest in Peru, it has been cultivated by indigenous people for centuries, and will grow in tropical climates up to altitudes of 1,700 meters. High potential across eastern slopes of Andes into Amazon basin. The seeds of sacha inchi have high protein (27%) and oil (35 - 60%) content. Growing domestic and international demand

- **Bolaina** *(Gauzuma crinita)* Fast growing timber with potential for smallholder. The species is an exceptional case of potentially sustainable smallholder forest management and timber production, processing and marketing

- **Babassu palm** *(Attalea speciosa)* Important alternative to palm oil and coconut oil. Used in food and cosmetics as well as a biofuel. It also acts as a pioneer species that can help colonize degraded and deforested areas. Its nuts produce rich oil and strong plant fiber. The spread of intensive agriculture and livestock production destroyed the babaçuais forests, and the introduction of cheap palm oil from Asia replaced babassu oil. Great regenerative potential in Brazil's Cerrado and Caatinga regions

- **Cañihua/Kaniwa** *(Chenopodium pallidicaule)* Quinoa-like, Cañihua is native to the Andean region, it has been farmed in the Altiplano for millennia. Tolerance of high mountain conditions, high content of protein and dietary fiber, and rich phenolic content. Protein, calcium, zinc and iron content is higher than that of more widely commercialized cereals. Cañihua is both easily accessible and drought-resistant, offering potential food and income for highland farmers

OPPORTUNITIES:

- There is a wealth of crops in South America, whose potential has not been tested in the marketplace. These range from normal food crops to superfoods, from fibers to timber, as well as plants with medicinal properties

- South America has many (unknown) food crops that are adapted to different climate extremes, which can potentially play a significant role in adapting to climate change, developing more food security, as well as create commercial opportunities for smallholder farmers

- Market demand for many existing novelty crops is projected to grow in coming years, yet are currently mostly grown in concentrated regions (Açai in Brazil), across similar climate types there are opportunities for South American countries to tap into those existing markets

RISKS:

- Hype around a crop can have a disruptive effect on local markets. A prime example is how intensifying demand for quinoa resulted in the local people giving up their quinoa in favor of international export resulting in increased food insecurity

- There is an inherent risk to developing and bringing to market crops that do not have large established markets. The marketplace for novelty crops can be volatile, and no farmer should depend on these crops for their income

LOCAL AND DOMESTIC MARKET CROPS

This list combines local market crops that cater to local and regional farmers markets, as well as crop recommendations for the domestic food markets at scale. The crop selection focuses on staple foods found in the South American domestic marketplaces, across the different climate types/regions: warm temperate Andean Highlands, humid and savanna tropical climates found across the north of South America and large parts of Brazil, as well as semi-arid or Arid Steppe climate found mainly in Brazil's Caatinga

A category that this list addresses is imports of vegetable oils and grains, which are two of Ecuador's main agricultural imports. Decreasing reliance on the global supply chain has proven particularly important in the current state of geopolitical uncertainty and the macro-economic inflationary environment. The Crop Compendium details many more species that are suitable to that end.


PAPAYA

LOCAL AND DOMESTIC MARKET CROPS

- **Coconut** *(Cocos nucifera)* Ubiquitous food that also has certain varieties that are particularly suited for the production of edible oil
- **Avocado** *(Persea americana)* Nutritive fruit as well as suited for the production of edible oil, although production costs can be high
- **Sunflower** *(Helianthus annuus)* Mainly cultivated in more temperate conditions for the edible oil, the leftover cake is very suitable as animal fodder
- **Peanut** *(Arachis)* Relatively easy to grow nitrogen fixing annual plant for tropical dry climates, which lends itself well to intercropping. For food and vegetable oil production
- **Mango** *(Mangifera indica)* Easy to cultivate, drought-tolerant, high-yielding fruit tree
- **Papaya** *(Carica papaya)* Very easily grown fruit with high yields. Highly suited to transitions to agroforestry systems
- **Banana/Plantain** *(Musa spp.)* High in starch and potassium. Needs water, combines well in agroforestry systems
- **Yam** *(Dioscorea spp.)* Tropical tuber crop. Ubiquitous energy food, high in starch. Amongst the major roots and tubers, properly stored yam is considered to be the least perishable
- **Tania** *(Xanthosoma sagittifolium)* One of the main energy crops in the South American tropics. Like Taro, big tuber. Easy to grow
- **Cassava** *(Manihot esculenta)* Most widespread tropical root crop grown for local markets and subsistence. Needs to be processed before consumption. Great soil conditioner, needs to grow in a diversified system that can replenish its nutrient needs

- **Corn** *(Zea Mays)* Many varieties, important staple starch. Important for food sovereignty and preservation of species diversity

- **Quinoa** *(Chenopodium quinoa)* Important Andean highland species. Highly nutritious staple food. The seeds are rich in protein, dietary fiber, B vitamins, and dietary minerals in amounts greater than many grains

- **Amaranth** *(Amaranthus caudatus)* Andean valley crop. Important staple. Many parts of the plant, including the leaves and seeds, are edible, and are frequently used as a source of food. Very high in protein and essential amino acids, such as lysine, which are typically deficient in plant protein

- **Breadfruit** *(Artocarpus altilis)* It is an introduced plant that has not become an industrial crop but has been domesticated as a source of carbohydrates in the diet and employed as medicinal or raw material for mestizo, Kichwa, Tsa'chi, Cofan, Secoya, and Shuar indigenous communities It is one of the highest-yielding food plants, with a single tree producing up to 200 or more grapefruit sized fruits per season, requiring limited care. A shade tree with low requirements easily incorporated into agroforestry systems

- **Soursop** *(Annona muricata)* Ecuador's national fruit, this versatile fruit is used in all kinds of popular foods, like desserts and drinks. It grows well up to 1200 m altitude and withstands very poor soils

- **Jaboticaba** *(Plinia cauliflora)* Grown mainly in the center of Brazil. They are tolerant of mild drought, and produce a flavorful fruit, which is made into juices and jellies

- **Pumpkin** *(Cucurbita spp.)* Popular vining and spreading food plant. Pumpkins are also called Calabas or Zapallo in South America. Stores well. Part of the three sisters: corn, beans, pumpkin

- **Rice** *(Oryza sativa)* Ubiquitous staple in South America. Grows at altitude in the Tropics. Needs a lot of water to grow. Difficult to compete with imports from large scale commercial operations

- **Sweet Potato** *(Ipomoea batatas)* Vining food plant with edible tuber, as well as edible leaves. Very popular starch crop

- **Cabbage** *(Brassica oleracea)* Grown in more temperate conditions at altitude in the tropics. Staple high nutrient vegetable, found in many local markets

- **Sweet Pepper** *(Capsicum annuum)* Native to Central America, brought to the Andean Highlands, called Aji in the Quechua language. Prefers warm and relatively dry climates

SOURSOP

CORN

OPPORTUNITIES:

- Instead of importing edible oils from a volatile global economic environment, there is an opportunity to produce these oils from various palm species including coconut, and the aforementioned babassu, as well as other oil-rich crops such as avocado seed, corn, and sunflower seed for the domestic market

- Cultivating native crops, like the many varieties of corn, quinoa, amaranth, and ramon, helps preserve cuisine and culture and are important aspects of local and domestic food sovereignty

- Perishable foods are more expensive to import and more difficult to export. As such, local markets provide a great opportunity for smallholder farmers to fill that gap

- Local markets provide a steadier source of income than the seasonal income from a single export crop

RISKS:

- Some smallholder grown crops have a particularly hard time to compete with large scale industrial production or imported equivalents. In certain cases like with rice it might not be possible to compete without price interventions

SUBSISTENCE CROPS

There is still a high incidence of poverty (48.6%) and extreme poverty (22.5%) across South America in rural areas. In Ecuador alone from 2017 to 2021 The poverty rate increased from 27.2% to 37.6% and extreme poverty rose from 10.7% to 19.2% due largely to the increase in unemployment, brought on in part by CV-19. (BTI, 2022) Since 2015, the poverty gap has widened when looking at factors such as access to basic public services.

In addition, the number of undernourished people has been increasing over the past decade, a situation that has been exacerbated by the Covid-19 pandemic, which according to the FAO is a problem related to the affordability of food by impoverished consumers, rather than the actual availability of food. (OECD - FAO 2019) In addition the Caatinga in the northeast of Brazil has the second highest prevalence of severe food insecurity in the country.

Despite Ecuador's economic growth, food insecurity, poverty and malnutrition are central issues. Climate change, conflict, Covid-19, and gender inequality impacts food security globally. UN Women's Zero Hunger Sustainable Development Goal Map shows that 32.7% of people in Ecuador are facing moderate or severe food insecurity. Increasing prices of energy, fertilizer, and agriculture inputs are also raising the prices of food and food production. (Selva 2022)

Andean Highland Farmers
Image Credit: Mongobay

Amazonian Indigenous Women Collecting Seeds in Panará Indigenous Territory
image Credit: Dannyel de Sá

TEMPERATE (TROPICAL HIGHLANDS)

- **Potato** *(Solana spp.)* Native to the Andean Highlands, like corn the amount of potato varieties across the Andean Highlands is staggering; within some communities up to a hundred different varieties are cultivated

- **Andean Walnut/Nogal** *(Juglans neotropica)* Native to the Andes; a threatened species with great cultural and ecological importance. Most abundantly in cloud forests. 'Tocte', the fruit of the Andean walnut, are often sold in the farmer's markets of Ecuador

- **Erythrina/Poroton** *(Erythrina)* Easy to establish nitrogen-fixing tree used in different kinds of agroforestry systems. Has edible pods that provide a secure stream of food

- **Achira** *(Canna indica)* Has been cultivated by indigenous peoples of the Andes for thousands of years. Grown for the starchy tubers. Highly perishable. Leaves used to wrap tamales

- **Ahipa** *(Pachyrhizus ahipa)* Andean Highland root crop. The carbohydrate-rich roots can be eaten raw and provide calories and vitamin K and vitamin C, as well as potassium

Girls in the Andean Highlands Showing their Potato Varieties Image Credit: Mongobay

- **Oca** *(Oxalis tuberosa)* Andean Highland root crop that can grow at high altitude. Very hardy species and important subsistence crop

- **Yacon** *(Smallanthus sonchifolius)* Traditionally grown in the northern and central Andes from Colombia to northern Argentina for its crisp, sweet-tasting, tuberous roots. The tubers contain bioactive compounds which are beneficial for human health

- **Cañihua/Kaniwa** *(Chenopodium pallidicaule)* Farmed in the Altiplano for millennia. Similar to Quinoa and Amaranth. Important crop for food security in the Andean region where there are nutritional problems. High content of protein and dietary fiber, rich phenolic content. Calcium, zinc and iron content is higher than most cereals


CASSAVA

TROPICAL HUMID - SAVANNA

- **Peach Palm** *(Bactris gasipaes)* One of the most important domesticated palm species in South America. Fast growing palm, with edible fruit. Needs processing
- **Breadfruit** *(Artocarpus altilis)* Easy to establish shade tree with very high yields, provides trace minerals and carbs
- **Banana/Plantain** *(Musa spp.)* Ubiquitous starch staple food in irrigated and humid tropical climates of South America. Integrated well in agroforestry systems, creates valuable mulch, leaves and particularly stalk
- **Cassava** *(Manihot esculenta)* Most widespread tropical root crop grown for local markets and subsistence. Needs to be processed before consumption. Great soil conditioner, needs to grow in a diversified system that can replenish its nutrient needs
- **Sweet Potato** *(Ipomoea batata)* Amongst the five most popular starchy tubers, mainly for carbs. Many varieties, edible tuber as well as leaves. Can vine or grow as a cover crop
- **Tania** *(Xanthosoma sagittifolium)* One of the main carbohydrate energy crops. Easy to establish, tuber is eaten, leaves are edible as well
- **Breadnut/Ramon** *(Brosimum alicastrum)* It was planted by the Maya civilization 2000 years ago. The breadnut is high in fiber, calcium, potassium, iron, zinc, protein and B vitamins, very high in antioxidants. Breadnut is nutritious and has value as a food source
- **Corn** *(Zea mays)* Native to South America, rich cultural history woven into its cultivation. Large diversity of varieties. Source of starch, flour, and oil
- **Bean** *(Phaseolus spp)* A staple Latin American food crop, nitrogen-fixing, easily grown, many different varieties. Easy to dry and store
- **Lentils** *(Lens culinaris)* A popular legume introduced to Ecuador and gained rapid popularity as subsistence crop because it is nutritious as well as easily dried and stored High content of protein and dietary fiber, rich phenolic content. Calcium, zinc and iron content is higher than most cereals

SEMI-ARID

- **Moringa** *(Moringa oleifera)* Easy to establish resilient tree crop with many uses. Edible leaves with a large range of essential trace elements
- **Carnauba palm** *(Copernicia prunifera)* Caatinga cornerstone species, 'tree of life' prized for Carnauba wax. Food, fodder, seed oil, timber, drought tolerant, high ecological value
- **Umbu** *(Spondias tuberosa)* Dryland fruit produced mainly in the Caatinga, nutritious as a subsistence crop and sold at local markets
- **Licuri** *(Syagrus coronata)* A palm native to the northeast coast of Brazil, it produces a nut that is edible and can be processed for oil
- **Cashew** *(Anacardium occidentale)* Native to South America, drought tolerant. Produces a fruit and a nut. Rich source of a variety of dietary minerals and vitamins
- **Maracuja do Mato** *(Passiflora galbana)* A passion fruit species that is native to the Caatinga. Produces a nutrient dense fruit similar to the well known passion fruit
- **Pitaya** *(Selenicereus undatus)* Has adapted to live in dry tropical climates with a moderate amount of rain. Produces a fruit also known as dragon fruit
- **Mangaba** *(Hancornia speciosa)* The plant provides an edible fruit that is popular and used locally, as well as a latex that has been exported in the past as a source of rubber

Image Credit: Marcondes Oliveira

OPPORTUNITIES:

- Food security is a real issue in Ecuador and other parts of South America. Growing subsistence crops alongside market crops is a good way for farmers to address that issue

- Nutrition is also an issue in many rural communities across South America. Growing subsistence crops gives farmers more agency to address nutritional deficiencies

- When farmers depend on income from produce for their food security, they are inherently subject to seasonal fluctuations and volatility. Growing their own subsistence crops provides them with greater potential year-round food security

- Growing subsistence crops to provide for farmer's food security diminishes the risks they run by being dependent on market place and supply chain disruptions

- Growing subsistence crops significantly reduces the economic costs for farmers dependent on marketplaces

- Growing subsistence crops is also a way for farmers to exercise increased food sovereignty, particularly when it comes to the preservation of the rich diversity of varieties of staple crops such a potatoes and corn in the Andean Highlands, as well as the many little known endemic species of the Amazon

RISKS:

- Farmers are afraid to sacrifice income from commercial crops to farm their own food

- Climate change and natural disasters are affecting large parts of South America and Latin America at large. The question of food security and viability of subsistence farming is tied together with the ability to create a farming operation that is able to withstand disruption and volatility, due to being well designed, adaptive, and resilient. Much of that comes down to the ability to work with the landscape and species diversification, both in food crops, plant support species, as well as animal incorporation

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Region-Specific Crops and Their Associated Market Opportunities and Risks
Southeast Asia

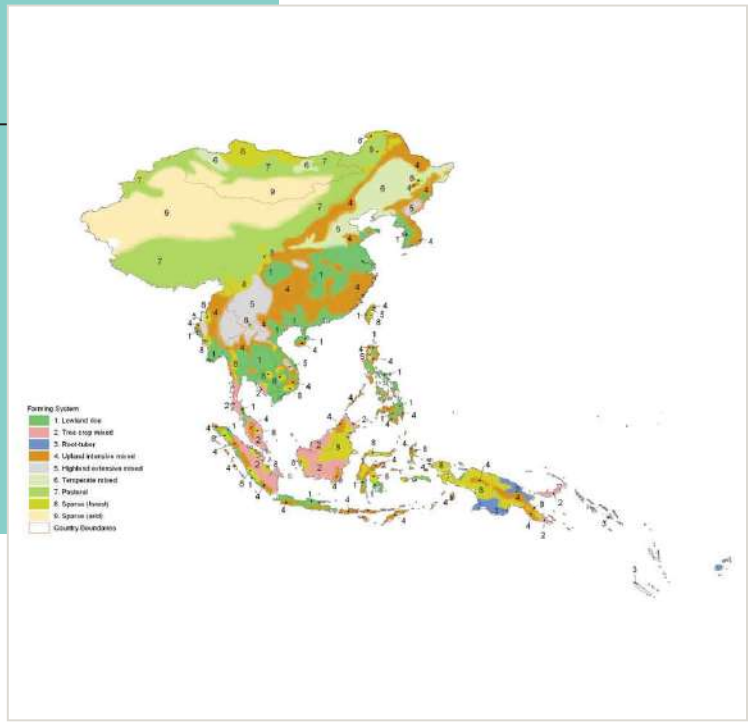

Image Credit: Dixon J and Gulliver A, Farming Systems and Poverty, 2001

CONTEXT

Southeast Asia is a uniquely rich region in terms of agricultural productivity and the diversity of high-value crops that thrive here. The region has become the world's leading exporter of key agricultural commodities such as rice, palm oil, coffee, coconut, and rubber. Unlike in many parts of the world, rainfall here is adequate for agriculture, allowing for many non-irrigated cropping systems. Southeast Asia is strongly influenced by the Asian monsoons, which bring a significant amount of rainfall to much of the region. Indeed, the two monsoon wind systems give the climate its distinctive regional character more than temperature variations. The continental parts of Southeast Asia – Myanmar, Thailand, Lao PDR, Cambodia, and Viet Nam – experience greater seasonality, more extremes in both temperature and rainfall, and more pronounced droughts, whereas the maritime countries of Malaysia, Singapore, Indonesia, and the Philippines have a stabler climate. (Chuan 2005)

The main broad farming systems are Lowland Rice Farming System, Tree Crop Mixed Farming System, Root-Tuber Farming System and Upland and Highland Mixed Systems, as depicted on the map above.

There is an enormous potential for regenerative agriculture in Southeast Asia, in part because of the liveliness of traditional agroecological and agroforestry practices. Rubber and the Wanakaset movement in Thailand for instance, is playing an important role in that regard. Here too, there is increasingly an imperative to explore the potential of secondary crops to increase the functionality as well as the viability of these regenerative agricultural production systems.

Historically, spices such as pepper, ginger, cloves, and nutmeg were especially important trade crops for the region. Wet-rice cultivation, an ancient form of agriculture, also remains dominant today. Export from the region today is dominated by a handful of key commodities:

- **Malaysia –** Palm oil, rubber, cocoa and wood products
- **Indonesia –** Palm oil, rubber, coffee, vegetables, and fruits
- **Vietnam –** Rice, seafood, coffee, cashew nuts, tea, and fruits
- **The Philippines –** Coconut oil, fruits, seafood, and tuna
- **Thailand –** Rice, rubber, sugar, fruits, processed tuna, and seafood

Agricultural output in Southeast Asia has been steadily increasing over the past three decades: Agricultural land area increased by nearly 40% across the region between 1980 and 2014. While giving the economy a boost,

> **"This agricultural expansion has come at a tremendous environmental cost. Southeast Asia lost about 80 million hectares of forest over the period 2005 to 2015, and the region continues to have one of the highest rates of deforestation of any major tropical region."**
>
> (MIKOLAJCZYK ET AL., 2021)

Monocultures of oil palm and rubber, as well as extractive aquaculture production, have all been major drivers of ecological degradation, now threatening not only biodiversity but agricultural productivity itself.

Southeast Asia is home to about 100 million smallholder farmers. Supporting these farmers in the adoption of more ecological growing practices is crucial to ensuring that agricultural production in the region develops in a direction where it is no longer coupled with environmental degradation. Diversified farming systems in which farmers cultivate more than one crop offer a compelling alternative to conventional monoculture cultivation.

The region has a rich legacy of indigenous traditions of diverse polyculture systems to draw on. Southeast Asia boasts numerous traditional, highly diversified agricultural systems, from tropical home gardens to integrated aquaculture systems such as the Javanese *pekarangan* or the Vietnamese duck-pond rice system (Lin et a. 2021). Indeed, aquaculture is vital to a distinctly Southeast Asian vision of ecologically nuanced agriculture (see the Memo "Beyond Terrestrial Crops: Aquaculture" later in this report). Thailand's river delta areas have practiced a system called *Yok Rong*, similar to the Chinampas in Mexico, in which the earth is dug to form finger-like canals on which various crops can be grown. In Southern Thailand, there is an ancient fruit forest garden system called *Som Rom,* which appears to draw on shared cultural heritage with at least Indonesia and Sri Lanka. In *Som Rom,* coconut and sometimes areca nut or durian constitute the peak canopy species. Below these, longkong, mangosteen, Burmese grapes, chempedak and snakefruit may be grown, and below them *cherimoya, gnemon* (a perennial vegetable), or different gingers. (M. Commons interview)

Currently, farmers' decisions about what crops to grow are largely determined by markets, rather than what crops and livestock would work well in an integrated system. Extension workers and aggregators have been key influencers in this decision-making process, sharing information about which crops have good markets. Nowadays, private companies' extension agents often recruit farmers to grow a certain crop.

Young farmers learn from social media and online channels such as YouTube and tend to be more innovative, trying out new crops.

How to build smallholder farmers' capacity and facilitate markets that support socially and ecologically regenerative growing systems? Three key ingredients to success emerge from research:

- **Multi-stakeholder partnerships:** Financing for smallholders in the region is fragmented and under-capitalized. However, a growing number of

> **"collaborative partnerships between investors, off-takers, development institutions and civil society are testing new ways of catalysing capital flow to smallholders and their transition to sustainable production methods. Technological advances in the fields of digital finance and big data analytics are unlocking new service delivery models in the agricultural space, strengthening the business case for investments."**
>
> (MIKOLAJCZYK ET AL., 2021)

- **Technical support and entrepreneurial capacity-building** for producers

- **Strong leading organization,** whether a producer cooperative, aggregator, or civil society organization (Ibid.)

This section provides a general analysis about agricultural markets in the region, as well as promising crops in the four categories used across this report. It should be noted that the research for this section uses Thailand as a starting point, zooming out into surrounding Southeast Asian countries as relevant.

General patterns affecting agricultural markets in the region

DEPENDENCE ON IMPORTS

Even as Southeast Asian countries are exporters of key agricultural commodities, they are also highly dependent on agricultural imports. Whether it's wheat for noodles, soybeans for cooking oil and tofu, or corn for animal feed, these dependencies make Southeast Asia vulnerable to sudden shortages and shocks in the international markets. Southeast Asia's top imports and dependencies include:

- Wheat
- Soybean
- Corn
- Dairy products
- Sugar

SHIFTS IN DOMESTIC DIETS

In the last two decades, the food markets in the region have undergone a transformation as Southeast Asian populations have shifted away from grains and starchy staples to meat, milk, eggs, fish, fruits, and vegetables. This is partially the result of urbanization and the increase of per-capita incomes. Currently, "high-value products such as fruits, vegetables, livestock products, and fish constitute a rapidly growing share of international trade in agricultural products," but there is also rising domestic demand for them. (Thapa and Gaiha 2014, 75-76) As a result, the agricultural economy is rapidly transforming, in ways that this region has not previously experienced or tested its carrying capacity for.

VULNERABILITY OF CONVENTIONAL MONOCULTURES:

Agriculture in the region is dominated by monoculture cultivation of the top export crops. Monoculture palm oil plantations in Indonesia have been the focus of the greatest international critique, but conventional monoculture cultivation of rice, rubber, coffee and fruits have also had degrading effects on the health of both farm ecosystems and farmer communities. Conventional monoculture rice cultivation, for example, emits large amounts of methane, creates biodiversity and human health risk due to extensive application of pesticides and herbicides, depletes freshwater resources and increases toxicity in waterways in areas where rice is grown intensively (three crops per year) with a high use of agrochemicals. (He et al., 2018)

CLIMATE CHANGE

Climate change is amplifying the risks to crops and infrastructure that leave smallholder farmers especially vulnerable. Global climate change scenarios predict that Southeast Asia's annual temperature will increase while winter rainfall will decrease. Rising sea levels will affect especially the region's coastal communities and island nations.

> **"Southeast Asia is possibly one of the most vulnerable areas in the global climate-change scenarios. Extreme climate events are expected to occur more frequently. The Philippines, Vietnam, Cambodia, Lao PDR, Thailand and Indonesia are among the countries identified as climate change 'hotspots"**
>
> (YUEN AND KONG 2009).

Natural hazards such as typhoons, droughts, floods and windstorms disrupt food production and compromise livelihoods and food security. Farmers need to cultivate the know-how to establish resilient agro-ecological systems that can weather climate extremes.

CONTRACT FARMING

Contract farming is the most popular and widespread agribusiness model in Southeast Asia. It is characterized by pre-arranged supply arrangements between buyers and smallholders. (Mikolajczyk et al. 2021) In contract farming, farmers are provided with seed, fertilizer, and technical assistance, as well as a guaranteed price at harvest time. Buyers are typically large agribusinesses. Contract farming has been seen as a way to overcome many of the challenges that smallholders face in accessing high-value commodity markets; however, to avoid exploitative schemes, the offtakers have to be fair and transparent. (Singh 2014) Unfortunately, contract farming rarely incentivizes the diversification of cropping systems; contract farmers are typically contracted to grow a single commodity crop.

CORRUPTION AND POOR GOVERNANCE IN SOME COOPERATIVES

Farmer cooperatives are one of the most significant factors in supporting smallholder farmers. Cooperatives and other farmer organizations can provide the needed solution to aggregating problems and provide extension support; however, in Thailand, for example, cooperatives are often dysfunctional (due to corruption and poor governance).

CROP RESEARCH

What follows is a selection of possible secondary crops that are important and/or hold promise across different levels of economic activity in Southeast Asia.

The crop lists that follow are indicative and should be read as recommendations. The decision about which crops are appropriate and have the greatest potential should always consider the specific place, climate, and context.

Throughout these lists, one major consideration is crops' suitability for diversified production systems.

EXPORT CROPS

The list below presents some of the most promising export crops in terms of compatibility with diverse cropping systems/agroforestry, and at least one of the following three factors: highly reliable existing commodity markets, a unique flavor or nutritional profile that will make it attractive to buyers, and a likely predictor of a continuing positive trend wave.

- **Cashew nut** *(Anacardium occidentale)*
- **Banana/Plantain** *(Musa spp.)*
- **Coconut** *(Cocos nucifera)*
- **Coffee** *(Coffea arabica, Coffea robusta)*
- **Rubber** *(Hevea brasiliensis)*
- **Moringa** *(Moringa oleifera)*
- **Rambutan** *(Nephelium lappaceum)*
- **Durian** *(Durio zibethinus)*
- **Pineapple** *(Ananas comosus)*
- **Lime** (and other citrus) *(Citrus spp.)*
- **Cassava** *(Manihot esculenta)*
- **Spices:** Cinnamon, cloves, nutmeg, chili pepper, turmeric, ginger
- **Rice** *(Oryza sativa)*
- **Kapok** *(Ceiba pentandra)*

OPPORTUNITIES:

- **Public-private partnerships:** This increasingly successful partnership model brings together governments and private sector companies (as well as potentially other players such as NGOs or researchers) to plan, finance and execute a project

- **Regenerative contract farming:** Contract farming could promote regenerative outcomes if the contract involves considerations of whole-system health, is based on fair and equitable agreements, and supports the diversification of both the farm ecosystem and the farmer's livelihood

- **Brand-sponsored value-adding facilities:** One effective mechanism for supporting smallholders' market access for diverse crops has been the support of an international market partner who may, for example, sponsor the construction of an aggregating or processing facility. This allowed one cooperative of cinnamon farmers in Vietnam to establish a packaging facility and diversify their farm systems to include additional crops such as star anise, turmeric, and ginger. In Thailand, such processing facilities are also often funded or co-funded by government agencies, particularly with cooperatives

- **The potential of promoting regenerative approaches among "middlemen":** Agricultural commodity traders and extension workers have considerable power over the system: they are often the ones informing farmers of what crops they should be growing, and in so doing they shape both farms and markets. One question for those wanting to foster and strengthen regenerative agriculture and markets is: how to promote regeneration among the "middle persons" – extension workers, traders, dealers, processors, and wholesalers?

RISKS:

- **Tendency of export markets to promote chemical-intensive growing practices:** Tropical fruits provide an attractive pathway for diversifying a cropping system. However, their relatively short shelf life requires effective market access and transportation. Many fruits are also currently grown in near-monocrop systems that are dependent on heavy doses of pesticides and other chemicals. Durian, for example, has become such a dominant, chemical-intensive monocrop fruit because there is a large market for it in China, and farmers can earn a lot per durian tree. However, their health may be compromised as a result of heavy spraying involved. Some of the tropical fruits also require fumigation or other treatment to be accepted for export

- **Farmers typically receive a significantly smaller percentage of the final sale price of the export product** because of the number of aggregators, wholesalers and other middlemen involved

EXPERIMENTAL CROPS

The crops below are standout "experimental" or novelty crops that do not have as of yet such established markets as the export crops, but hold promise for finding and expanding their niche within export markets. (The word "novelty" refers to novelty within commodity export markets; many of these crops are in fact traditional or indigenous crops that have been used as food and medicine for centuries.)

Some of these crops already have emerging markets, although with relatively small market sizes. They include some "superfoods" that are driven by global consumption trends, but markets for these crops may be more volatile than some of the guaranteed export crops. Other crops such as galip nut have negligible existing markets, but they hold great cultural significance and have great novelty crop potential.

BREADFRUIT

EXPERIMENTAL CROPS LIST

- **Galip nut** *(Canarium indicum)* –
  a wonderful indigenous nut grown especially in Papua New Guinea and other Pacific islands. The nut can be both grown and foraged. Pilot projects have demonstrated the profitability and demand for Galip nut and the fact that it can be processed and produced commercially for export (ACIAR 2022)

- **Kava** *(Piper methysticum)* –
  Kava is grown and consumed in the South Pacific islands, where it is consumed as a traditional ceremonial beverage due to its mildly sedative effects. In recent years, kava root extract has been discovered by the supplement and nutraceuticals industry. The relaxing properties of kava have led to a considerable rise in market demand. The global kava root extract market is projected to grow from $1.18 billion in 2022 to $3.41 billion by 2029.

- **Breadfruit** *(Artocarpus altilis)* –
  The breadfruit tree is a really resilient tree in agroforestry systems, and breadfruit is highly nutritious – high in complex carbohydrates, low in fat, gluten-free and a good source of fiber and minerals. There is an existing local market for fresh breadfruit in many parts of Southeast Asia; however, the plant has export potential as well. Breadfruit can be ground up into gluten-free flour. In addition to flour, breadfruit chips and dough are important value-added products.


LANGSAT

- **Pili nut** *(Canarium ovatum)* –
  Already has an established export market, with a market value of USD 1.78 billion. Vietnam and Indonesia each represent only about 1% of the total export market; Southeast Asia's total market share could increase as the climate is well-suited to grow Pili nut.

- **Sacha inchi** *(Plukenetia volubilis)* –
  A rich source of omega-3, along with other essential nutrients. Sacha inchi's roasted seeds are commonly consumed as a snack; the ground seeds can be used as an ingredient in protein powder and other food products. The global sacha inchi market witnessed a healthy growth in 2018-2022, driven by the rising demand for superfoods. The market is further expected to grow (Source).

- **Gnemon** *(Gnetum gnemon)* –
  The nutritious seeds can be eaten as a snack like peanuts, boiled, roasted, or raw. They can also be ground up into flour. Interesting phytochemical properties.

- **Konjac** *(Amorphophallus konjac)* –
  very high dietary fiber. Konjac is gluten-free and has potential in food products such as pasta and noodles. It has a wide array of other product applications such as food additive, thickener, and food jams. Konjac powder can also be used in cosmetic products such as shampoo, and in animal feed. These qualities are driving a strong demand in the market.

- **Kwini** *(Mangifera odorata)* –
  A relative of mango, this rather sour-tasting fruit has potential as a value-added product, especially in chutneys. It is high in dietary fiber, vitamin C, and vitamin E.

- **Langsat** *(Lansium parasiticum)* –
  Has potential for the health food market: the fruit has high antioxidant content. The peel is often consumed as a medicine. The seed extract is also a rich source of limonoids. Nutritionally rich, with many beneficial elements such as proteins, carbohydrates, minerals, fiber, Vitamin A, thiamine and riboflavin.

- **June plum** *(Spondias cytherea)* –
  some is grown for export but the market is still only emerging; the fruit is a little sour with hints of mango and pineapple and is popular around the world but still has a niche status.

OPPORTUNITIES:

- **Potentially less competition** for early farmer adopters of these crops, assuming they are able to connect with a reliable buyer

- Many of these crops **integrate well with agroforestry/ polyculture** cultivation systems

- **Storytelling and raising cultural awareness about unique crops:** Opportunity to promote and highlight culturally significant, yet lesser-known crops, and the communities that have traditionally grown them, at an international scale

RISKS:

- New crops may be **risky and involve significant investment**

- There is a danger that the **commercialization of these crops could do damage** to either the ecosystems in which these crops are grown, or to the communities that hold traditional ethnobotanical knowledge about their uses. (See the Memo "Domestication of Indigenous Crops")

Image: Jackfruit at a market in Thailand Image Credit: Gerard Vonk

LOCAL AND DOMESTIC MARKET CROPS

There has been a very strong development of local organic or ecological markets in Southeast Asia over the last 20 years, including renewed interest among urban consumers in local traditional crops and varieties, as well as increased recognition of traditional medicine. All of this would support the development of local regenerative markets. Supermarket chains have also emerged as important buyers of produce in Southeast Asia.

According to our expert interviews, the strongest economic position for farmers would include at least one key economic/export crop (such as rubber, rice); home use crops (rice, fruit, veggies, fish, eggs); local market crops sold two times per week (M. Commons interview, V. Panyakul interview).

The crops below hold great potential as crops that could be adopted and promoted for local and domestic markets.


MANGOSTEEN

LOCAL AND DOMESTIC MARKET CROPS LIST

- **Breadfruit** *(Artocarpus altilis)* -
  Besides being a promising emerging export crop, breadfruit deserves a place in a list for local market crops as well. Many Southeast Asian countries import starches such as potatoes and grains, whereas they could be using more breadfruit which grows locally. Breadfruit is high in complex carbohydrates, low in fat, gluten-free and a good source of fiber and minerals. It is a nutritionally higher quality protein than imported starchy foods. (Breadfruit People, 2019)

- **Cempedak** *(Artocarpus integer)* -
  similar to its relatives breadfruit and jackfruit, can be eaten as a fruit or vegetable and has many applications in Southeast Asian cuisines

- **Bitter bean** *(Parkia speciosa)* -
  a popular regional culinary ingredient

- **Burmese grapes** *(Baccaurea ramiflora)* -
  a popular fruit locally, with good nutritional profile and medicinal properties

- **Konjac** *(Amorphophallus konjac)* -
  gluten-free, high in fiber, a number of different potential applications

- **Langsat** *(Lansium parasiticum)* -
  highly nutritious, as mentioned above

- **Longan** *(Dimocarpus longan)* -
  fruit similar to Litchi. Important in Chinese medicine and has a market in Chinese communities around the world

- **Mangosteen** *(Garcinia mangostana)* -
  a relative of mango with great potential. Needs to be fumigated for export markets, so may be a better fit for local markets

- **Star apple** *(Chrysophyllum cainito)* -
  fruit used locally as a dessert fruit

- **Sugar palm** *(Arenga pinnata)* -
  Sap collected for sugar; also starch, fibers, leaves for basketry

- **Sago palm** *(Metroxylon sagu)* -
  starch used locally for tapioca balls

- **Santol** *(Sandoricum koetjape)* -
  fruit can be eaten raw or cooked; popular ingredient in many regional cuisines

- **Salak** *(Salacca zalacca)* -
  popular to-go snack in much of Southeast Asia

Image Credit : Flo Dahm on Pexels.com, Street Scene in Hanoi, Vietnam

OPPORTUNITIES:

- Campaigns to **revive and promote regional cuisines, healthy diets and ecologically sound production methods** through the development of local and regional markets

- Fewer intermediaries are needed to access local markets, meaning **farmers typically receive a higher percentage of the final sale price**

- It may be difficult for farmers to export perishables. Therefore, local markets are **best positioned for farmers to sell perishables,** thus enabling farmers to diversify their harvests. Perishable foods are also more expensive to import, so local markets of perishable crops will not have to compete with imports as often

- **Local markets provide weekly/biweekly income for producers,** versus export crops which more often only are harvested and sold once or twice a year

RISKS:

- As diets in the region are shifting to include more wheat, meat and dairy products and in general more “Western” type foods, it is possible that the demand for regional specialty produce and specific traditional Southeast Asian herbs, spices, flavorings and unique vegetables will decrease in the coming years and decades

SUBSISTENCE CROPS

Lastly, this section presents the top subsistence and food security crops for the Southeast Asian region, noting that not all of them will be suitable for all regions.

Food security is an important consideration. More than 320 million people in Southeast Asia live in extreme poverty, and two of the countries in the region (Myanmar and Lao PDR) are among the poorest countries in Asia. Natural disasters (such as typhoons, earthquakes, and floods) happen every year. As noted above, the region is dependent on imports of key agricultural commodities such as wheat, corn, soybean, sugar, dairy and even rice. International supply chain disruptions, made markedly worse by Covid-19 and the Russia-Ukraine conflict, have led to increased food prices. In the case of Vietnam, food insecurity has led to food nationalism. (Calicutan, 2022)

Image Credit: Steve Douglas on Unsplash

SUBSISTENCE CROPS LIST

- **Banana/Plantain** *(Musa spp.)*
- **Breadnut** *(Artocarpus camansi)* - a balanced carbohydrate
- **Breadfruit** *(Artocarpus altilis)* - a versatile, large fruit
- **Jackfruit** *(Artocarpus heterophyllus)* – also widely planted for nutritious subsistence
- **Djenkol** *(Archidendron pauciflorum)* – The seeds, called beans, have a higher protein content than many legumes. A popular snack in Southeast Asia and are prepared by frying, boiling, or roasting and are also eaten raw. The seeds are mildly toxic due to djenkolic acid
- **Elephant foot yam** *(Amorphophallus paeoniifolius)* – excellent source of carbohydrates and often grown as a "famine crop"; native to Southeast Asian islands
- **Sweet potato** *(Ipomoea batatas)* - root crop more likely to withstand extreme weather events
- **Cassava** *(Manihot esculenta)* - root crop more likely to withstand extreme weather events
- **Moringa** *(Moringa oleifera)* – Edible (highly nutritious) leaves, seeds and fruit pods
- **Bitter gourd** *(Momordica charantia)* - promising research on health effects
- **Pigeon pea** *(Cajanus cajan)* - a drought-resistant, resilient legume; good source of protein
- **Rice** (*Oryza sativa)* Ubiquitous staple crop
- **Wild yams** *(Dioscorea spp.)* Traditionally important for subsistence and climate resilience and also fit in agroforestry systems

OPPORTUNITIES:

- Diversifying cropping systems with these reliable high-calorie, high-nutrition crops is an insurance policy in the event of extreme weather events and other unforeseen emergencies. Karen Mapusua of IFOAM Organics shares that farmers in the Pacific Island already know how to grow "famine crops" such as cassava and sweet potatoes in case of typhoons and flooding, and know to harvest them right away before they rot

- Food security is a real issue in many parts of Southeast Asia. Growing subsistence crops alongside market crops is a way to ensure year-round food supply

- Growing subsistence crops gives farmers more agency to address nutritional deficiencies

- Growing subsistence crops to provide for farmer's food security diminishes the risks they run by being dependent on market place and supply chain disruptions

- Growing subsistence crops is also a way for farmers to exercise increased food sovereignty, ensuring access to culturally relevant and culturally significant foods

RISKS:

- Smallholder farmers may perceive including food sovereignty crops within their small acreage to present a risk, as it reduces the area available for growing market crops

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Region-Specific Crops and Their Associated Market Opportunities and Risks
Sub-Saharan Africa

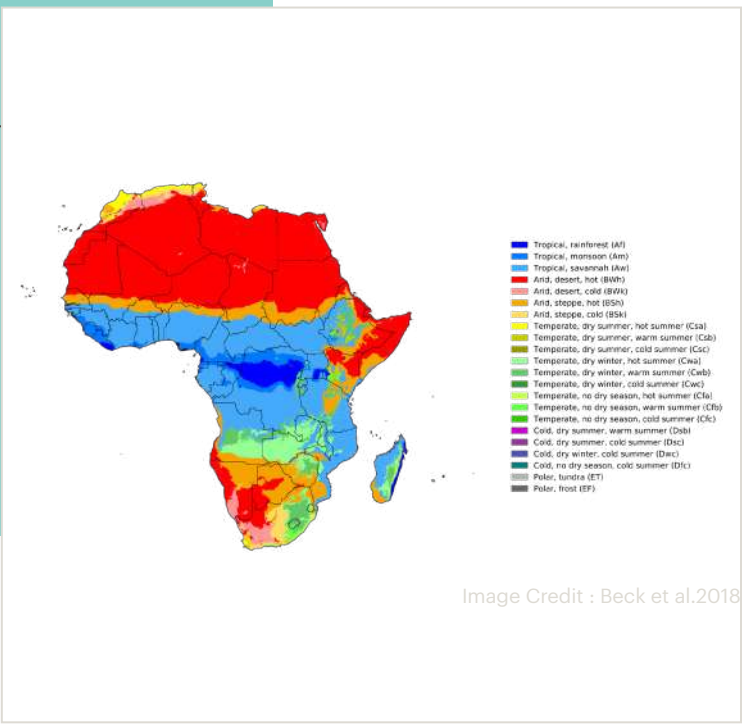


Image Credit : Beck et al.2018

CONTEXT

In trying to describe a productive approach to promoting regenerative agriculture in Sub-Saharan Africa, it is important to recognize both the sheer size and cultural-ecological diversity of the region, as well as its legacy of resource extraction by foreign entities. In the context of exploring how bringing secondary crops to market can serve as a productive tactic for the revitalization of land, communities, and local and national economies, both diversity and legacy affect the opportunities and risks that have revealed themselves while researching for this series of reports.

The main broad farming systems are Lowland Rice Farming System, Tree Crop Mixed Farming System, Root-Tuber Farming System, and Upland and Highland Mixed Systems.

In terms of regenerative agriculture there is a significant potential in Subsaharan Africa to address questions of ecological fragility as well as improved livelihoods, whilst emphasizing issues surrounding food security and food sovereignty. Exactly for these reasons it is pivotal to explore the role that secondary crops might play in the Subsaharan African context, and understand better how diversified production systems relate to global, regional, and domestic markets.

The vast majority of smallholder farmers (<2 ha) are found in the western and central regions along with the Horn of Africa, while more scattered in the southeast, and with a notable absence in the southern portion of the continent. Most smallholder farmers are therefore found in regions with the following three broad climate classifications, although local conditions will of course vary greatly:

- Tropical savanna
- Humid tropical
- Warm semi-arid

The organization of smallholder farmers, their support networks, and paradigms of agriculture also vary greatly, although there is general agreement that poverty, hunger, and malnutrition are widespread problems, and that the agricultural production potential of the region is much higher than what is currently being realized. This is particularly the case when it comes to Sub-Saharan Africa providing its own food security and sovereignty. Bringing secondary crops to market can be a helpful pathway to address all of these, but first it is important to make some general observations mainly relating to the public discourse on what the future of agriculture should look like in Sub-Saharan Africa.

Image Credits: Anthony Desrochers on Pexels.com

General regional patterns affecting the potential for bringing secondary crops to market

COMPETING PARADIGMS OF AGRICULTURAL SYSTEMS

The double edge of the Green Revolution of the 1960s has been written about extensively, and while its complex legacy is beyond the scope of this report, it is important to note that the underlying logic and assumptions that drove the Green Revolution are still very much represented in discourse on the future of Africa's agriculture, particularly at a policy level, with significant pushback from local and regional organizations that see continued resource extraction and dependence on agribusiness, along with land evictions, as integral elements to the Green Revolution model of agriculture (see e.g. Tittonell et al., 2022; Teal & Moss, 2022).

The risk here is that the further promotion and application of resource-intensive agriculture dependent on high levels of mechanization, the homogenization of plant communities, the consolidation of seed production and distribution by larger companies promoting hybridized seeds, and application of synthetically derived fertilizer, pesticides, fungicides, and insecticides will only serve to further degrade soils and ecological health while increasing the strain and pressures on farmers and their communities (Wise, 2020; Vyawahare, 2022; UNEP, 2020).

The term regenerative agriculture is itself highly contested within Africa, as it is often seen as an American and Euro-centric approach to agriculture rooted in multinational companies and development schemes that pay less attention to other farming methods, unfamiliar crops, and forms of organization having their origins within the continent itself.

It is also seen as paving the way for continuous exploitation of farmers and communities, as the term is often used to focus on soil health and carbon while leaving out questions of power relations, equity, and health. This is a fair criticism, and it must be acknowledged that the skepticism against imposed and introduced programs is founded on a large collection of real-life examples. The kind of regenerative agriculture this series of reports aims to promote is closer to what is widely referred to as agroecology across the continent, which also highlights the socio-political environments at play in agricultural systems (Teal & Moss, 2022).

A NETWORK WITH SMALLHOLDERS' INTEREST AT THE HEART IS ALREADY ON THE RISE

An often-quoted statistic estimates that there are about 33 million smallholder farms in Africa contributing up to 70% of the continent's food supply (IFAD, 2014), and beyond the farmers there are networks of service providers, entrepreneurs, and local and regional markets making up constellations of food and other produce systems.

The Alliance for Food Sovereignty in Africa (AFSA) serves as an umbrella organization with more than 40 member organizations in 50 countries, with an estimated reach of 200 million people representing all elements of the food system. It promotes working toward food sovereignty with a whole systems view including questions of justice, equity, territorial rights, governance, traditional knowledge systems, seed sovereignty, climate crisis, and agro-biodiversity based in large parts on native species as key to the discourse on agriculture and development in Africa.

Campaigns such as My Food is African speak directly to this systemic approach being put in action to promote local and regional market development. The plant lists below reflect this focus on native and endemic species that are particularly well adapted to local growing conditions – current and projected – as well as possessing significant cultural and ecological value as part of their economic promise.

CLIMATE CHANGE IS LIKELY TO INCREASE THE INTENSITY OF EXISTING WEATHER PHENOMENA

The Notre Dame Global Adaptation Initiative points to the African continent as being both the most vulnerable region overall on Earth and the least ready to face the challenges expected. For the agricultural sector, the northern and eastern arid and semi-arid regions of the continent are expected to become drier along with the southern plateau in South Africa, Namibia, and Botswana, while the general expectation for the more humid regions are shorter, more intense rainstorms.

Major challenges are therefore to adapt production systems that are suitable to drier regions and cultivating systems that are better suited to capture, store, and slowly release the humidity that is available in the form of short and intense rainfalls. This is key to ensure complete hydrological cycles with water trickling through the ground and replenishing aquifers.

Multi-strata polycultures are excellent production systems to facilitate this in places with sufficient precipitation, while dynamic animal husbandry is likely to be key in sustaining the more grass-dominant dryer regions. Increased mitigation capacity and overall resiliency of both agro-ecological systems and human communities will be greatly increased with diversification and dynamic management based on place-specific knowledge and regenerative governance processes rather than introduced generic technologies.

This is seen for example in parts of the Sahel, where areas with functioning collective governance and land tenure stability are able to steward land on an upward trajectory of health and functioning diversity (Worms, 2022).

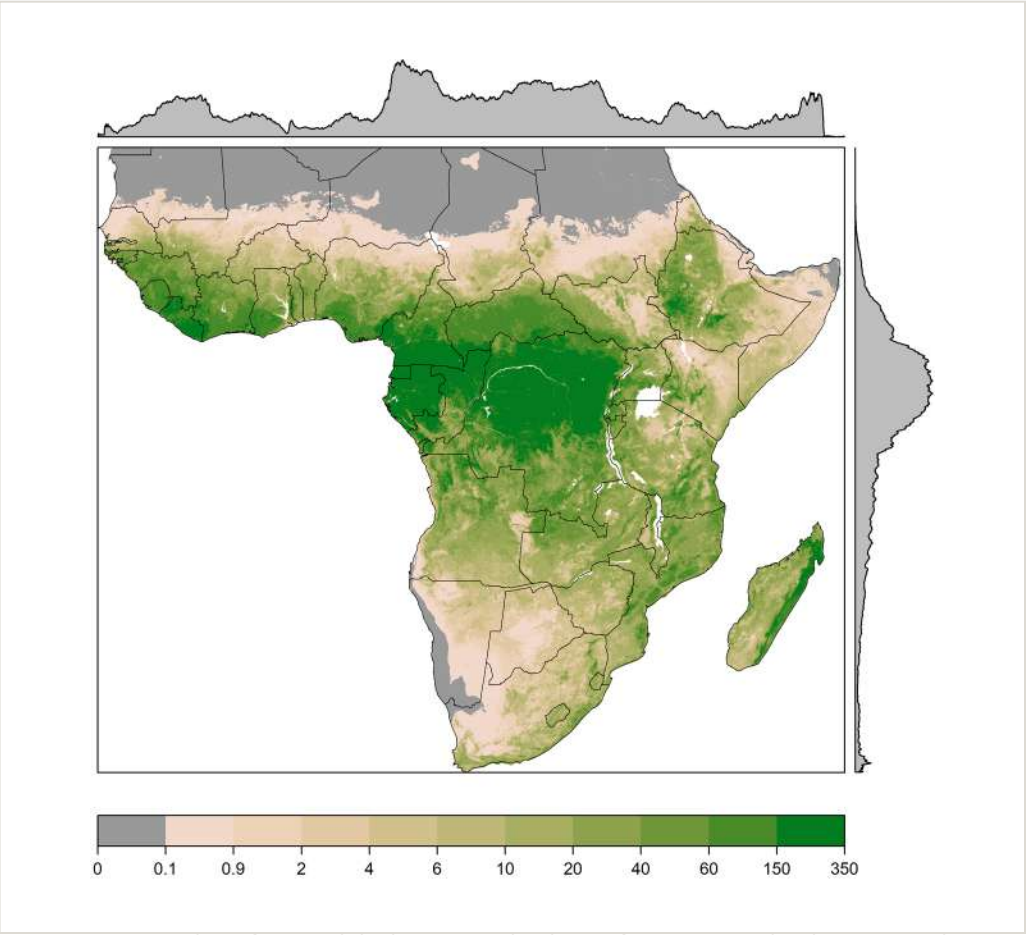


Image: Relative forest and shrub cover in sub-saharan africa Image Credit: daac-news.ornl.gov

CLIMATE CHANGE IMPACTS AND UNRESOLVED SOCIAL CHALLENGES CHANGE THE DEMOGRAPHIC OF SMALLHOLDING.

In several African countries, the men in the family leave to seek economic opportunities elsewhere, leaving women to take on added tasks and responsibilities on farms. Women are the ones who often face more barriers to access land, finance, and other necessary resources (Hazell and Rahman, 2014).

Several women's support groups exist more or less formally and enable women to support each other with loans, labor, knowledge exchange, and community. Herein lies also an opportunity for other entities to support the social capital these groups represent (AFSA, 2022). Many rural young people also find themselves without work opportunities or access to resources, with increasingly fragmented family plots, pressures of population growth, competition from larger investors, and increasingly degraded lands (Ibid.).

The true potential of regenerative agriculture lies in holistically considering all these factors as part of one system, to work systemically to revitalize the land while also addressing socio-political challenges and opportunities.

DOMESTIC DEMAND AND FOOD ORIGIN AWARENESS ARE ON THE RISE.

Rapidly rising populations, increasing urbanization, and rising incomes are all at the heart of reports speaking to the promise of the African market. A growing urban middle class is becoming more interested in the origins and effects – to their own health and to that of farmers and the biosphere – and segments also appear to have a growing interested in heritage crops from the continent, although some of these crops still have reputations as "famine" or "poor people's" food.

This represents a market pull that is expected to grow, and if more service providers and policies were looking to source from and support smallholder farmers practicing agroecology, access to local, national, and regional markets could be greatly improved. This market potential is also often referred to in the form of shifting consumption from "less formal" to "more formal" forms of commerce. While this might be desirable overall, it is important to note that formalizing locally, domestically, and regionally is a very different route than formalizing through the introduction of multinational supermarkets.

FOOD SOVEREIGNTY CROPS

A common narrative relating to Africa in general is its dependence on imported grains, especially wheat and Asian rice as staples, while having large amounts of arable land and native and/or long-cultivated alternative grains available. State policy, multinational companies, and philanthropic foundations have for decades promoted industrialized mass production of imported and hybridized strands of maize, wheat, and rice, alongside a generally declining interest in native grains among consumers, although there are signs of both awareness and interest changing that will favor native and traditional grains in internal markets.

Image Credits: Dark Shades on Pexels.com

GRAIN CROPS FOR FOOD SECURITY AND SOVEREIGNTY

- **Fonio** *(Digitaria exilis / D. iburua)* - Once the major food in dry savannas and probably the oldest cereal in Africa, fonio is still an important staple or a major part of the diet for millions of people in several West African countries. Highly valued for its flavor, it occupies important cultural significance in the regions where it is cultivated. Some varieties are also extremely fast-growing, producing grains within 6-8 weeks (42-56 days) of planting, while others mature much more slowly (165-180 days). Among the grains native to the African continent, fonio has been tipped as being in the best position to have its production increased as it is already quite widely cultivated, highly rated, and tolerates poor growing conditions (Lost Crops of Africa Vol. 1)

- **African Rice** *(Oryza glaberrima)* - Cultivated in three systems: dryland, paddies, floating gardens. Considered to have limited commercial farming potential due to comparatively weak yield and ease of processing compared Asian varieties (for example, hulling is more difficult), but – besides the cultural tradition and agro-biodiversity argument for cultivating these varieties – they do cope better with impoverished soils, compete better with weeds (a significant benefit when considering labor limitations), mature quicker than Asian varieties (100-125 days instead of 130-170 days), and are also the preferred choice as the are experienced as more filling. There is therefore a valuable potential as subsistence crop and also for local markets

- **Finger millet** *(Eleusine coracana)* - There are many varieties of millets, some of which are considered more appropriate as subsistence crops, while some also hold commercial promise. Common for all is their tolerance of dry and challenging growing conditions – and invaluable characteristics in times to come. Fast-growing varieties mature in 90 days, and the species is also considered to be very promising for selective breeding because of this quality

- **Pearl millets** *(Pennisetum Glaucum)* - A crucial food security crop in some of the harsher semi-arid regions

Image Credit: Sznu, Creative Commons License

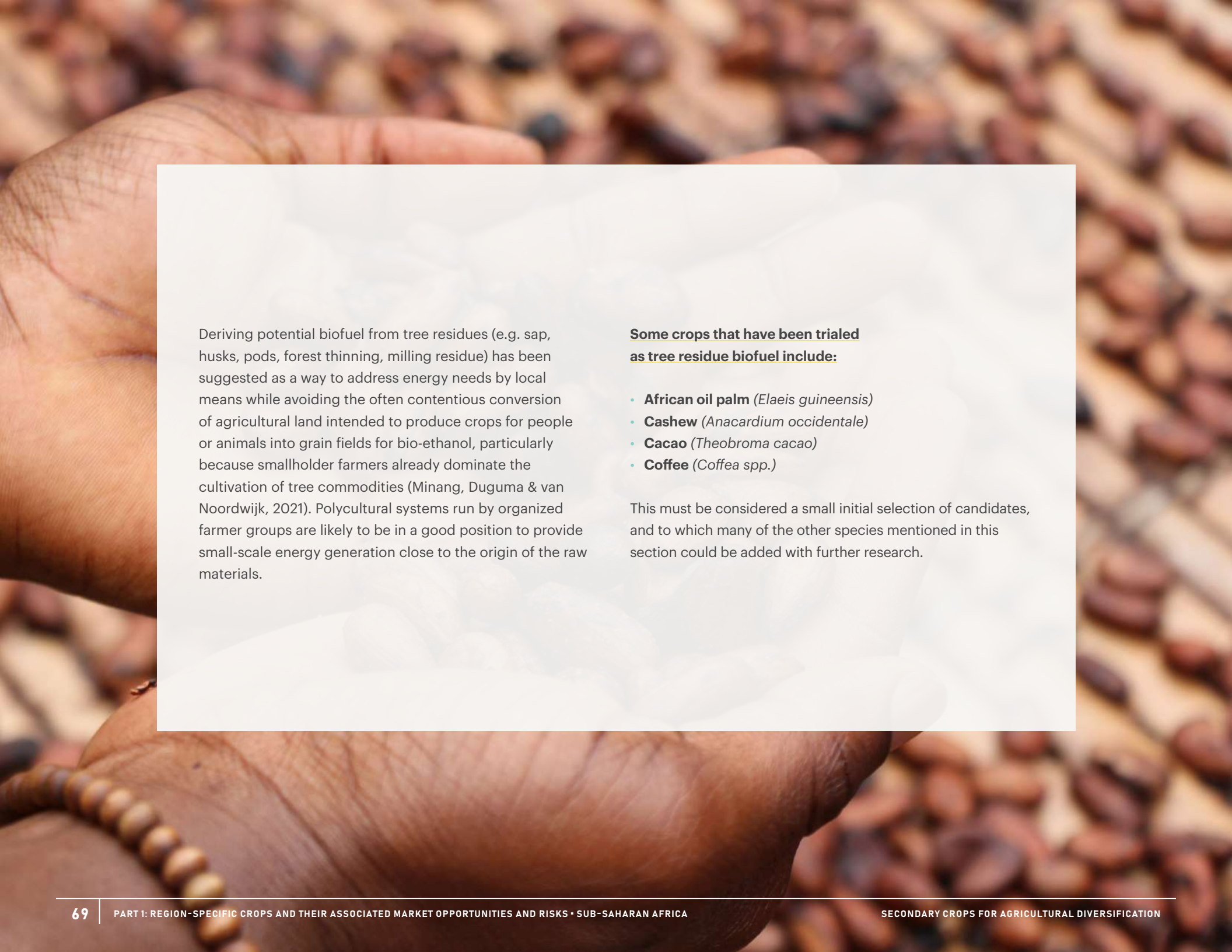
- **Sorghum** *(Sorghum bicolor)* - Arguably not a secondary crop, as it is a major staple and among the five main cereals in the world, but it still holds great potential with its tolerance for poor growing conditions and fast maturation time (75 days). Cultivating multiple varieties of sorghum to ensure genetic diversity and adaptation to local conditions will be key

- **Teff** *(Eragrostis tef)* - A staple grain to the Horn of Africa and main ingredient in injera bread, teff has been seeing a gradual increase and spread in cultivation over the past decades, although its tough labor requirements may hold back any major increase. Central to Ethiopian and Eritrean cuisine, it has likely market opportunities beyond these borders, and potentially as high-value export grain

- **Emmer** *(Triticum turgidum)* - Originating in the Near East, emmer is believed to have been cultivated in Ethiopia for at least 5,000 years. The trend over the past decades has been to increase its production in the highlands, and so emmer is likely well-positioned to reach national and regional markets

OIL PRODUCING CROPS

- **Aizen/Hansa** *(Boscia senegalensis)* - shrub native to the Sahel, with edible fruit and seeds with long traditions of use
- **African breadnut** (Treculia africana) - "potentially the world's most productive source of edible protein" (Toensmeier 2016)
- **Baobab** *(Adansonia digitata)* - savannah tree with multitude of uses, including edible fruits, seeds (also oil), leaves, and more
- **Dika nut** *(Irvingia gabonensis)* - humid tropical tree renowned for its nuts made into "dika bread/Gabon chocolate", seed oil, and highly valued wood
- **Sweet detar** *(Detarium senegalense)* - 'forest' and 'savannah' types exist, popular fresh fruits that also dry and store well, high value timber, promising in dry areas in particular, but also in humid ones
- **Butterfruit** *(Dacryodes edulis)* - highly revered tree especially in West Africa. High protein-calorie crop, grows in challenging conditions, a nutritional superfood
- **Moringa** *(Moringa oleifera)* - edible leaves, nutritional superfood, also used for water filtration, fast growing
- **Shea butter tree** *(Vitellaria paradoxam)* - key species in the West African savannah, with highly valued kernel oil that retains a solid shape also in warm environments. Highly valued locally and highly sought-after internationally
- **African oil palm** *(Elaeis guineensis)* - given a poor reputation due to extensive planting of cleared forests as monocultures, the African Oil Palm is unrivaled in its ability to produce both fruit and kernel oils. Currently being imported from Asia to several West and Central African countries (PFAF 2022)
- **African locust bean** *(Parkia biblobosa)* - highly treasured seeds especially in Sahel region
- **Jujube** *(Ziziphus mauritiana)* - highly valued fruit that also stores well
- **Egyptian Balsam** *(Balanites ægyptiaca)* - bitter fruits, with valuable medicinal properties, durable wood and good quality charcoal



Deriving potential biofuel from tree residues (e.g. sap, husks, pods, forest thinning, milling residue) has been suggested as a way to address energy needs by local means while avoiding the often contentious conversion of agricultural land intended to produce crops for people or animals into grain fields for bio-ethanol, particularly because smallholder farmers already dominate the cultivation of tree commodities (Minang, Duguma & van Noordwijk, 2021). Polycultural systems run by organized farmer groups are likely to be in a good position to provide small-scale energy generation close to the origin of the raw materials.

Some crops that have been trialed as tree residue biofuel include:

- **African oil palm** *(Elaeis guineensis)*
- **Cashew** *(Anacardium occidentale)*
- **Cacao** *(Theobroma cacao)*
- **Coffee** *(Coffea spp.)*

This must be considered a small initial selection of candidates, and to which many of the other species mentioned in this section could be added with further research.

Image: Civil Eats

OPPORTUNITIES:

- Most grains and trees **native to Sub-Saharan Africa have received comparatively little interest among researchers and many consumers compared to other, more internationally well known and imported species** (Minang, Duguma & van Noordwijk 2021; AFSA 2021; Lost Crops of Africa Vols. I-III). Including and improving crops through **farmer-led research-participatory domestication initiatives,** as has been done with the bush mango *(Irvingia gabonensis)* can provide highly valuable new understanding, skills development, and multiple varieties adapted to specific places

- While farmer training and knowledge exchange are often quoted as important on the production side, relatively less attention is often given to skills and networks relating to **marketing, processing, and packaging** of raw materials, creating bottlenecks where farmers are not able to have their secondary crops reach a market or command a worthwhile price for a distinguishable product (AFSA 2022)

RISKS:

- **Many indigenous and traditional agricultural practices can readily be considered "regenerative" or "agroecological",** and represent an invaluable source of knowledge and skill as such, but can in many cases be **dismissed as archaic** and hence lose status compared with other practices considered more progressive or 'modern' (Uzonsu, 2021)

- Any quest to improve native plants must not come at the cost of not preserving natural genetic diversity, as this will decrease the genetic diversity pool available within a species and weaken its capacity for resilience and adaptation (Anegbeh et al. 2003; see memo on biodiversity)

- A number of small-scale bio-energy projects have been attempted in Sub-Saharan Africa, with limited success, citing lack of preparatory planning, organizational challenges, inhibitory expense of setting up a processing plant, and meeting consistent quality as key obstacles (Minang, Duguma & van Noordwijk 2021). Again, attention must be given to place-specific conditions as well as holding adequate capacity and capability-building processes for farmers and their communities, not just to implementation of a technology or method

EXPERIMENTAL CROPS

The following list represents a small selection of crops that have appeared as potential experimental export crops, for specialty markets or potentially some larger scales, as additional value from plants that are suitable to be grown for food security and sovereignty purposes.

MARULA

- **Gumvines** *(Landolphia spp. / Saba spp.)* -
  Native and reasonable latex producing vines which previously supplied much of the continent with natural rubber before being superseded by the Brazilian rubber tree (Hevea brasiliensis). Also has valued fruits

- **Baobab** *(Adansonia digitata)* -
  Flour from dried fruits and nuts have potential to be explored

- **Butterfruit** *(Dacryodes edulis)* -
  Highly valued oil for cooking and cosmetics, adding to its existing value for local use

- **Marula** *(Sclerocarya birrea)* -
  Valued fruits and oil from the nuts for skin use

- **African Rice** *(Oryza glaberrima)* -
  A valued diversification to Asian rice varieties, with potential specialty market

EXPORT CROPS

The main export crops from Sub-Saharan Africa are mainly tropical commodities such as cacao, cotton, coffee, cashews, and tea, while a number of the species mentioned in the lists above are also being introduced to specialty markets. Important to note, however, is the fact that although we tend to think of e.g. cacao as a main crop rather than a secondary one, cultivating diverse cacao varieties within polycultural systems is shown to result in higher quality crops, healthier plants and ecosystems, more diversified incomes and better life quality for farmers and their extended communities (Cacao of Excellence; Interview). Hence, the inclusion of crops such as cacao in this list is to highlight that they do best and have the most valued contribution when cultivated within polycultural systems. The following crops are already exported at larger scales or have been found to hold particular potential as export commodities:

DIKA NUT

Image: The Roaming Fork

- **Cacao** *(Theobroma cacao)*
- **Coffee** *(Coffea spp.)*
- **Moringa** *(Moringa oleifera)* - Rapid growth can make this an appropriate income crop that already has international market
- **Cashew** *(Anacardium occidentale)* - While Africa is a major exporter of cashew nuts with 59% of global production, value return to the region is often low as nuts are sold unprocessed. Additional potential lies in exploring oil and bio-energy potential (Minang, Duguma & van Noordwijk, 2021)
- **African Rosewood** *(Guibourtia demeusei)* - Highly valued timber and Congo copal ingredient
- **Dika nut** *(Irvingia gabonensis)*
- **Ebony** *(Diospyros spp.)* - Highly valued timber
- **Enset** *(Ensete ventricosum)* - Potential fiber otherwise regarded as waste after harvest
- **Tree grapes** *(Lannea spp.)* - Highly valued fruits and potential fiber source
- **Jujube** *(Ziziphus mauritania)* - Highly valued fruit that also stores well
- **Gum Arabic** *(Acacia senegal)*
- **African oil palm** *(Elaeis guineensis)*
- **Pearl millets** *(Pennisetum glaucum)* - Commercial and/or specialty varieties
- **Fonio** *(Digitaria exilis / D. iburua)*
- **Cassava** *(Manihot esculenta)*
- **Tamarind** *(Tamarindus indica)* - Besides the fruit pulp itself, exquisite syrups are made in e.g. Burkina Faso and Mali

OPPORTUNITIES:

- Tree crops already represent some of the region's fastest growing land uses, with at least five countries being single tree commodity dependent economies (Minang, Duguma & van Noordwijk, 2021). This represents a great opportunity for perennial, multi-strata polycultural systems, which – if not being implemented to the detriment of established ecologies – provide multiple benefits to the farmers and their communities. A key question here is who will fund the transition to more complex polycultures and the training of farmers able to manage these systems (Interview)

Low commodity prices and limited processing capacity means that most crops are sold as raw materials rather than as value-added products. For example, evidence suggests that although 75% of the world's supply of cacao is grown in Africa, the continent only captures about 10% of the commodity's market value (Minang, Duguma & van Noordwijk, 2021). Developing appropriate value-adding infrastructure is therefore a key element in improving local financial return

Togo is one example where government policy supportive of organic agricultural products has led to a rapid increase in exports to the European Union in recent years, positioning it as the second largest African exporter of organic agricultural products after Egypt (Uzonsu, 2021). Many government policies in the region are currently still focused on promoting industrialized forms of agriculture based on bio-fortification and application of synthetic agrochemicals. A shift along the lines of Togo will play a significant part in enabling the scaling of regenerative forms of agriculture

Having a distinguishable product alongside sufficient aggregation capacity, quality packaging, storage, and transportation are frequently highlighted as bottlenecks

RISKS:

- There is a lack of skill and knowledge distribution among many smallholder farmers for managing more complex production systems, so promoting planting material and implementation of cultivation systems without an accompanying attention to developing the skills and knowledge needed among farmer communities to manage complex polycultures risks leaving the transition falling flat (Interview)

Image Credit: CIFOR

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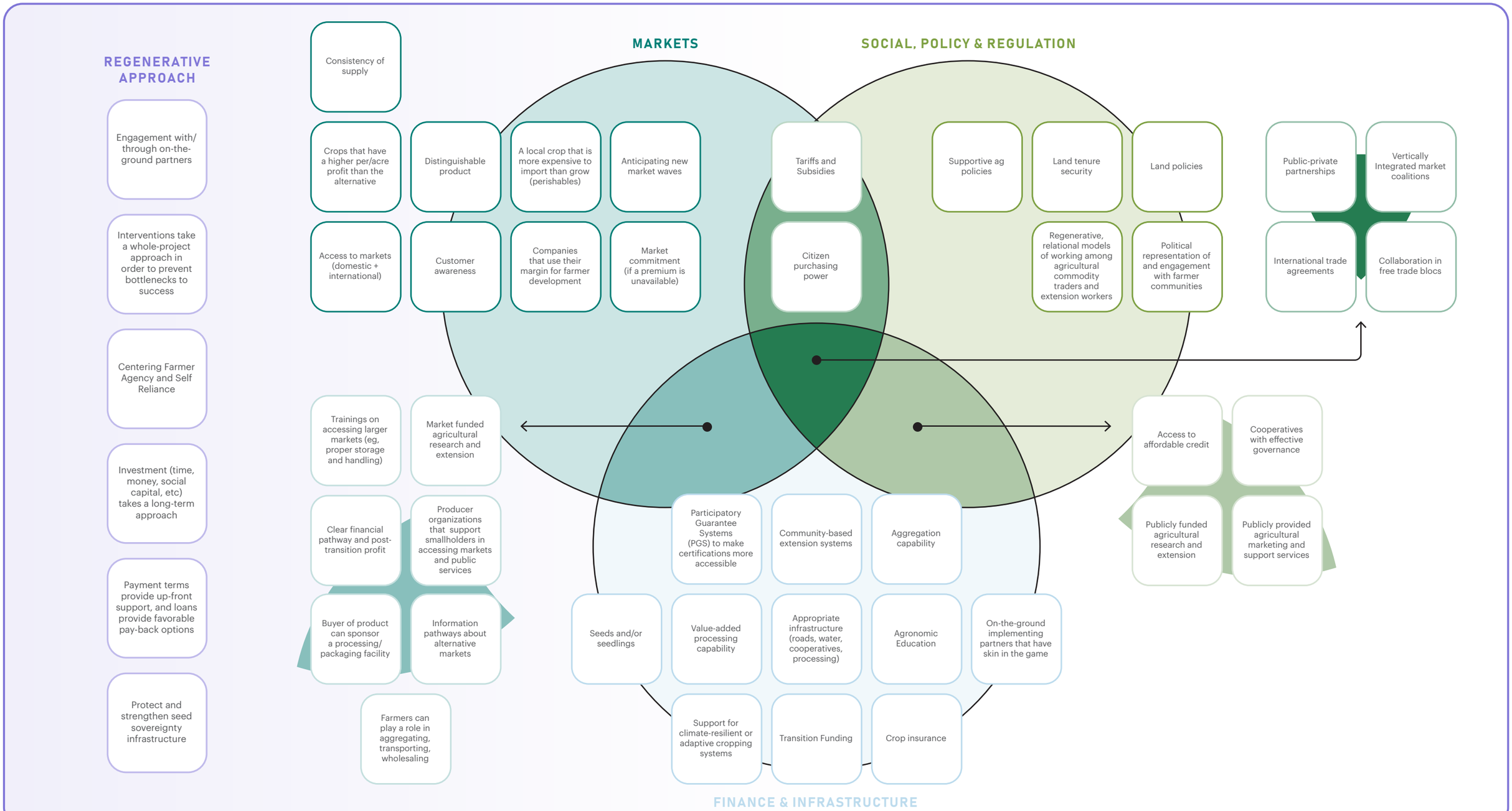
Part 2:

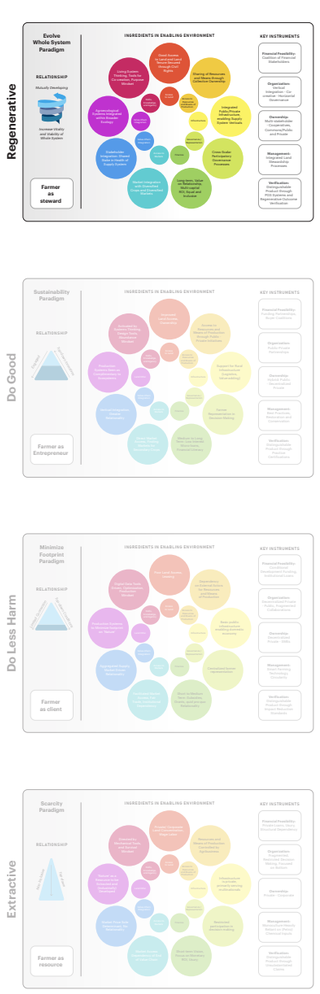
Market Pathways Diagrams

Enabling Environments



Market Pathways

Levels of enabling environments for bringing secondary crops to market in a smallholder-focused system



Regenerative

Evolve Whole System Paradigm

RELATIONSHIP

Mutually Developing

Increase Vitality and Viability of Whole System

Farmer as steward

INGREDIENTS IN ENABLING ENVIRONMENT

- Good Access to Land and Land Tenure Secured through Civil Rights
- Living System Thinking, Tools for Co-creation, Purpose Mindset
- Sharing of Resources and Means through Collective Ownership
- Access to Land
- Skills, Knowledge, and Agency
- Access to Resources and Means of Production
- Agroecological Systems Integrated within Broader Ecology
- Value-Chain Integration
- Infrastructure
- Integrated Public/Private Infrastructure, enabling Supply System Verticals
- Value-Chain Integration
- Governance / Representation
- Stakeholder Integration: Shared Stake in Health of Supply System
- Access to Markets
- Finance
- Cross-Scalar Participatory Governance Processes
- Market Integration with Diversified Crops and Diversified Markets
- Long-term, Value on Relationship, Multi-capital ROI, Equal and Inclusive

KEY INSTRUMENTS

Financial Feasibility: Coalition of Financial Stakeholders

Organization: Vertical Integration - Co-creative - Horizontal Governance

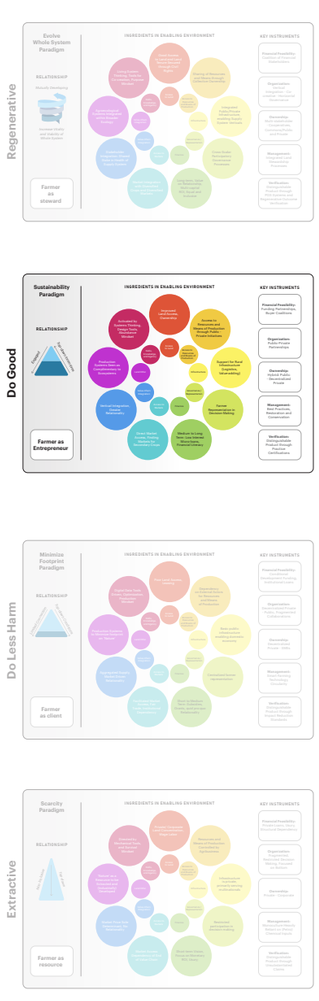
Ownership: Multi-stakeholder - Cooperatives, Commons/Public and Private

Management: Integrated Land Stewardship Processes

Verification: Distinguishable Product through PGS Systems and Regenerative Outcome Verification

Market Pathways

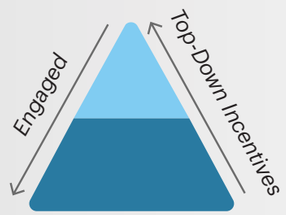
Levels of enabling environments for bringing secondary crops to market in a smallholder-focused system



Do Good

Sustainability Paradigm

RELATIONSHIP



Farmer as Entrepreneur

INGREDIENTS IN ENABLING ENVIRONMENT

KEY INSTRUMENTS

Financial Feasibility:
Funding Partnerships, Buyer Coalitions

Organization:
Public-Private Partnerships

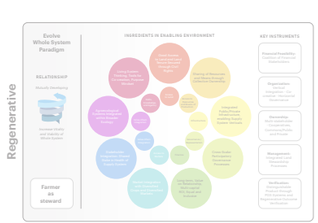
Ownership:
Hybrid: Public - Decentralized Private

Management:
Best Practices, Restoration and Conservation

Verification:
Distinguishable Product through Practice Certifications

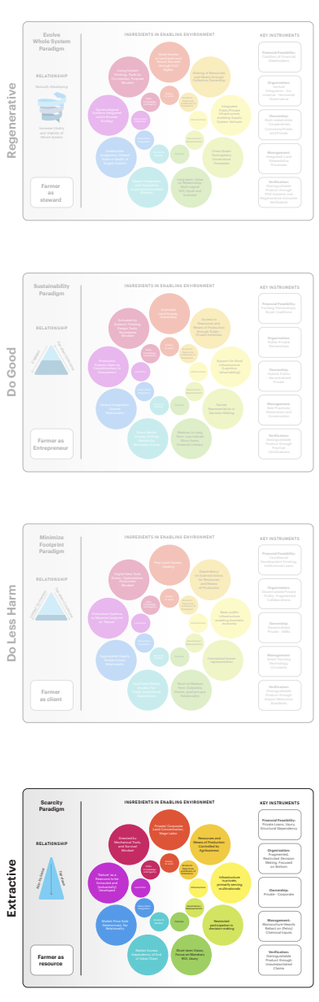
Market Pathways

Levels of enabling environments for bringing secondary crops to market in a smallholder-focused system



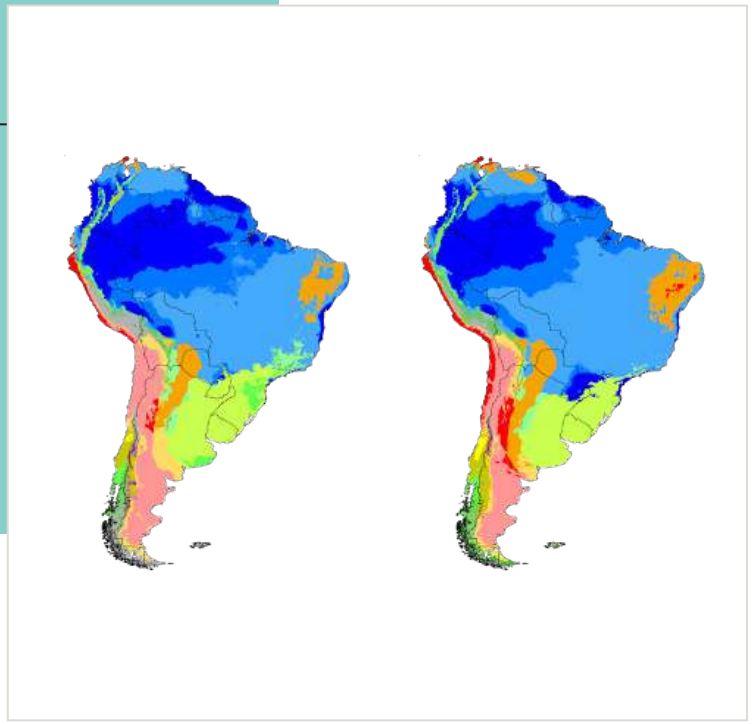
Market Pathways

Levels of enabling environments for bringing secondary crops to market in a smallholder-focused system



Part 3:

Crop Memos



Köppen climate maps visualizing the projected effects of climate change on climate types across South America in the next 50 years. A trend observed worldwide | Image Credit: (Beck et al. 2018)

CLIMATE RISK AND THE CONSEQUENCES FOR SMALLHOLDER AGRICULTURE

IMPACT

Climate change has had a significant and noticeable impact on the world in recent years, with temperature extremes, more intense rains, and frequent droughts having a major effect on agriculture and smallholder farmers. Climate change will create warmer and drier environments, increasingly variable rainfall regimes and more frequent climate extremes (Siyum, 2020). Just a 2°C temperature increase risks substantial decreases in some crop yields grown by the 396 million of the approximately 900 million people involved in agriculture, which would severely impact livelihoods, food security and wellbeing unless adaptive measures are implemented (Roy et al., 2018).

These variances in climate are set to become more extreme over time, and have in certain areas (especially in the tropics) already caused devastating effects on the agricultural sector, leading to:

- Higher temperatures
- Temperature volatility
- More frequent droughts
- Decreased crop yields
- Lower water availability
- Increased soil erosion

The maps on the previous page, show the general transition toward drier and hotter climate types in South America, a similar scenario is set to play out worldwide. Climate change may shift ecological zones in tropical mountains and affect tree species distributions (Watts et al., 2022) . A generic model implies a climate shift from colder and wetter to hotter and drier; within the context of this research and observed in the Köppen climate assessments by Beck et al. 2018, a shift from Tropical Rainforest and Tropical Monsoon to Tropical Savanna and Arid Steppe, as well as from Warm Temperate to Subtropical, is observed. Undoubtedly leading to more vulnerability in terms of food production and food security.

Flooding in West Africa
Image Credit: The Climate Centre

Droughts are more frequent and last longer
Image Credit: Welthungerhilfe

SMALLHOLDER FARMERS

This trend has been and will continue to be particularly damaging for smallholder farmers, who often lack access to the resources and technologies needed to adapt to changing climate conditions. The result has been a decrease in yields, and an increase in poverty levels for smallholder farmers, as they are unable to generate enough income to support their families. Smallholder farmers are one of the most vulnerable groups to climate change, yet efforts to support farmer adaptation are hindered by the lack of information on how they are experiencing and responding to climate change. (Harvey et al., 2018)

In addition to affecting crop yields, climate change also affects the health of smallholder farmers. Higher temperatures and more intense rains have led to an increase in vector-borne diseases such as malaria, dengue fever, and Zika, which have caused a significant increase in the number of deaths in the farming communities around the world. (Campbell-Lendrum 2015)

It also means that many areas may not be able to support the same kind of crops, and in general ecosystems as they do now. There will be a shift to more drought and heat tolerant species. This has significant implications for commodity export crops, food security, the agricultural sector at large, and the smallholder farmers as part of that system.

ACTION PATHWAYS

What is appropriate in any particular context can only be discovered by cultivating a deep understanding of that place and context. This approach is key to developing the right kind of policies, strategies, and interventions. More information is needed on how different types of smallholder farmers vary in their perceptions and responses to climate change, and how to tailor adaptation programs to different smallholder farmer contexts. (Harvey at al., 2018)

In general agricultural ecosystems need to become much more resilient, and various studies point toward diversified tropical agroforestry systems as a key point of intervention with high impact. (Watts et al., 2022) In line with the enabling environments that are conducive to the kind of evolution that is needed in smallholder agriculture, the Natural Resources Institute emphasizes the following principles to support a transition to climate resilience:

- **Decentralized** – to cope with the diversity and local specificity of smallholder systems
- **Participatory** – to build on farmer knowledge, and to cope with complexity of farming systems and livelihoods
- **Multi-stakeholder** – to incorporate wider perspectives (public and private), and to feed up knowledge into policy and government and donor investment
- **Gender-aware** – as women's role in developing country agriculture, and their particular vulnerabilities to climate change, can too easily be overlooked

(Morton, 2012)

In addition a number of specific interventions are identified as areas of high impact in the regions discussed:

- Providing smallholder farmers with access to resources and technologies that can help them adapt to changing climate conditions. For example efficient low cost irrigation systems (Rueda, 2023)

- Providing support for farmers to transition to more climate-resilient crop species and varieties. For example, farmers in some tropical regions in the Caribbean have transitioned to growing cacao instead of coffee due to the increased climate risk of coffee trees (Dessources, 2023)

- More generally, facilitate the development of place appropriate (regenerative) interventions. In many existing agricultural production systems this means transitioning to diversified agroforestry systems that are designed to accommodate climate volatility. Strategies could include planting cover crops, windbreaks, planting on contour, multi-strata cultivation, and cultivation over short, medium, and long term production cycles; benefiting from the climate regulating characteristics of multi-strata natural ecosystems

- Education on the effect of climate change and possible pathways to mitigate, and adapt to the changing circumstances are key

Climate change is a phenomenon that affects everyone and everything on the planet. If humanity is to adapt and transition to a healthy relationship with the environment through our agricultural practices, it will be important that the health of the environment and the planet at large is an issue that all feel they have a stake in, are responsible for, and feel empowered to act upon.

Image: Multi-strata agroforestry system in Thailand

Image Credit: helpstopthesmoke.org

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CROPS PARTICULARLY CONDUCIVE TO REGENERATION

When it comes to creating resilient communities and ecosystems, not all crops should be treated the same. As defined through this report, conditions like climate suitability, market fitness, and farmer preference should be considered when promoting the integration of crops into agricultural systems. In addition to these considerations, additional factors may help to determine how well a crop may facilitate the process of regeneration in a place.

From an ecological perspective, crops that can introduce additional strata to an agricultural system provide significant benefits. Often, this stratification is primarily supported by the addition of tree species, if they do not already exist in the cropping system. The addition of tree crops significantly increases the chances of regeneration due to providing habitat for wildlife (if suitable to the ecological context), slowing and capturing rainfall, and cooling the microclimate (Gardiner, 2020).

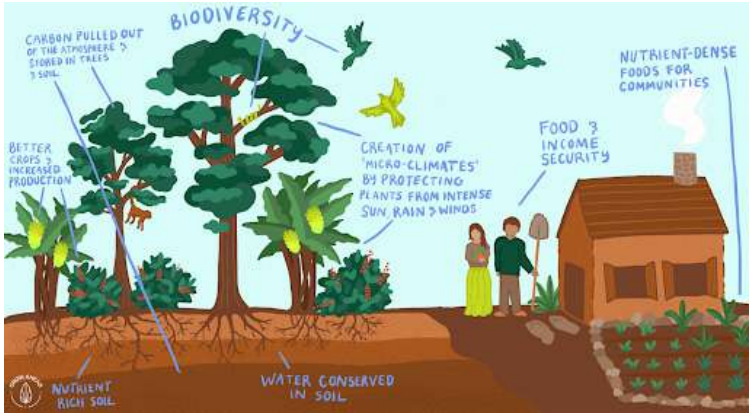

Image: Benefits of Agroforestry Image Credit: Grow Ahead

The addition of trees also has a significant impact on farmer livelihoods. Trees can serve as a windbreak, thus protecting more vulnerable crops below. They also help to stabilize soil in significant rain events. By providing a cooler microclimate, trees can improve working conditions (Gardiner, 2020). And, the combination of short lived annual crops and perennial trees and plants can help to diversify and strengthen financial returns, given that healthy perennials provide harvest for years on end (Regeneration.org, 2014).

There are other important roles a crop may play in an ecosystem to support the process of regeneration:

- Nitrogen-fixing crops bring an important balance to soil health and can notably reduce farmers' reliance on synthetic fertility inputs
- Cover crops used to keep the soil covered, suppressing weeds, holding moisture and protecting the soil life. Often these crops can double as nitrogen-fixers, fodder, and/or green manure
- Native crops, especially flowering ones, can support as pollinator species. Aiding in proliferation of beneficial insect species as well as the process of pollination
- Crops of cultural relevance can significantly support socio-cultural regeneration. Often times these crops are the most adapted to local conditions, supporting food security as well as potentially playing a role in developing more food sovereignty
- Crops for niche local uses, such as construction, artisanry, and medicinal plants, can support with food sovereignty and community coherence and integration (Moteane, 2022; Kirby et. al. 2023)

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BEYOND TERRESTRIAL CROPS: AQUACULTURE

Typical images the term *regenerative agriculture* conjures include a handful of healthy soil, a diversified palette of flora and fauna, beautiful countryside landscapes. While these are vital elements of a healthy biosphere, there has until very recently been a noticeable terrestrial bias within the 'regenerative space'. All the regions included in this report have extensive waterscapes, from headwaters to streams and rivers, wetlands to estuaries, mangroves and coastlines, with phenomenal potential for improved ecological health and community vitality, that need to be considered within a holistic view of regenerative systems of cultivation.

Reports of over-exploitation of fish stocks globally is familiar news, and the same is true for ocean acidification and the pollution of waterways, often through leaching of novel agrochemicals from crop production on land. With global awareness and concern about the omnipresence of petroleum-derived plastics – and single-use packaging in particular – one of the most promising alternatives that has been pointed to is in the form of macro-algae such as kelp. There is currently a growing hype around kelp cultivation, and particularly around its potential for packaging as bio-plastics, but also as a food source (including alternative protein) and additive, a fiber source, pharmaceutical applications and several other uses, promoted with impressive statistics concerning rates of growth. Seen as the connected system that it is, kelp is an important organic fertilizer in many coastal regions (REF), and with the global supply of mined phosphate (of which Morocco is the main exporter) rapidly decreasing, kelp could also take on a vital role in ensuring availability to the necessary organic nutrients needed for annual crop cultivation.

Image: Cathing Tilapia in a smallholder aquaculture farm in Kenya Image Credit: LVN Embassy Nairobi

There is undoubtedly great potential for ecologically healthier sourcing and practices connected to kelp and other associated aquatic crops, but this comes with the cautionary tale we have become familiar with on land: for ecological health to be ensured and for local communities to be able to reap the benefits of this potential for self sufficiency and

surplus tradable goods, locally appropriate aqua-ecological systems driven by local communities need to be at the center of this development. *3D Ocean Farming or Integrated Multi-Trophic Aquaculture* are some of the more industrially derived terms for such diversified systems, which incorporate secondary crops that complement – ecologically, nutritionally, and financially – a primary crop or livestock (e.g. sugar kelp or salmon). From a more traditional and indigenous perspective, there are numerous examples of diverse use and cultivation of aquatic species across all regions included in this report – freshwater and saltwater based – and several with thousands of years of practice (Costa-Pierce, 2002). One example is the Thai *Yok Rong*, a cultivation system similar to the more well-known *Chinampas* (or floating gardens) in the Valley of Mexico, and fish-based farming systems found across Africa, some of which trace back at least the past 9000 years (Dixon et al., 2019).

As water is commonly a limiting factor in the expansion of regenerative agriculture and agroecological approaches – particularly in certain regions of Sub-Saharan Africa – it is key to hold healthy water cycles in mind when identifying production systems with truly regenerative potential. The floodplains of Nigeria, the Sokoto fadamas, for example, have alongside the Niger River delta in Mali been places where African rice varieties have been cultivated for thousands of years in "floating fields", an example of how flooding events and flood-prone landscapes can be seen as a productive opportunity rather than a hazard to be minimized (National Research Council, 1996). And identifying how appropriate aquacultures and aquatic crops can function as tools or strategies in enabling the establishment of healthier hydrological cycles would be a valuable supplement to the recommendations outlined in this set of reports.

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DOMESTICATION OF INDIGENOUS CROPS: CONSIDERATIONS

For thousands of years, rural people have gathered wild plants for food, medicine, building materials, and fodder. Tree products – nuts, fruits, bark, edible leaves, and roots – have been a particularly important aspect of traditional ethnobotanical knowledge. With the expansion of modern agriculture, many of these plant species have become scarce as forests have been cleared to make space for the cultivation of annual staple crops. Yet literally thousands of plant species, especially in the tropics and subtropics, remain that have both edible and medicinal value, are often highly nutritious, and provide a critical food security.

In recent decades, there's been a revival of interest in these indigenous crops by both scientists and the food and pharmaceutical industries. Tree crops, in particular, have been at the center of attention. Among the indigenous tree crops that have gained the most interest in Africa, for example, are baobab *(Adansonia digitata)*, eru *(Gnetum africanum)* and marula *(Sclerocarya birrea)*. The mighty baobab is not only highly adaptable to adverse climate conditions, but also phenomenally versatile: every part of

Traditional seed selection of finger millet in India Image Credit: Nawraj Gurung

the tree is used; its fruits and leaves are high in vitamins. Over 300 uses for baobab have been recorded across the African continent. No wonder then, that:

> **"Baobab products — leaf, fruit pulp and seed kernels — are widely marketed and have been approved for trade as 'novel food' in the European Commission."**
>
> (LEAKEY ET AL. 2022, 2355)

For the Pacific Islands, such indigenous crops include kava *(Piper methysticum)* and Galip nut *(Canarium indicum)*; for Ecuador and Peru, they include morete *(Mauritia flexuosa)*, ungurahua *(Oenocarpus bataua)*, and chontaduro *(Bactris gasipaes)*.

Community-based domestication and commercialization programs have done valuable work propagating and breeding indigenous crops and providing farmers with training and access to plant materials. The World Agroforestry Centre (ICRAF) has been engaged in an effort since the 1990s to domesticate high-value indigenous trees for agroforestry through a participatory breeding process – an important intervention to alleviate poverty, malnutrition, hunger and land degradation (Ibid.)

Even with all the promise of indigenous tree crops and other crops, it's important to note three primary concerns that arise with their commercialization. First of all, commercialization could easily lead to over-exploitation of indigenous crops. Indigenous tree crops, in particular, are

> **"severely prone to over-exploitation and extinction as forests recede due to deforestation and the fact that they are being cut down for medicinal purposes without replacement [which] can result in genetic erosion and reduction of the regenerative capacity of the species as the seeds are being removed from their natural environment."**
>
> (IBID., 2355)

Secondly, developing international markets of indigenous crops can damage local supply and diminish local dietary diversity. Quinoa is perhaps the best-known example of this detrimental effect. This highly nutritious pseudo-cereal with adaptive qualities was a staple food for indigenous people of the Andean region over centuries. But when quinoa was "discovered" by the global superfood economy, its price rose dramatically – by 600% from 2000 to 2008, to a point where the local people in Bolivia and Peru could no longer afford to eat their traditional staple food. (Source)

Thirdly, commercializing indigenous crops raises questions about intellectual property – specifically, how to protect traditional knowledge from commercial exploitation. There are cases of exploitative entrepreneurs mass propagating and marketing – even patenting – the plant cultivars painstakingly bred by smallholder farmers over long periods of time, drawing on their traditional ethnobotanical knowledge.

Currently, there are no international legal mechanisms to support the property rights of farmers who can't afford legal counsel. IP legislation has been mostly focused on protecting the interests of companies. Juliana Santilli has provided some of the best existing thinking in her *Agrobiodiversity and the Law,* noting that establishing IP rights for plant varieties developed by farmers would also have a downside:

> **"IP rights mean exclusion and monopolies over seeds, both of which tend to discourage the free circulation of agricultural resources and knowledge, undermining the bases of local and traditional agricultural systems."**
>
> (SANTILLI 2012)

Leakey and Lombard (2010) highlight the example of PhytoTrade Africa, which promotes the sustainable harvest and commercialization of natural products derived from indigenous plants in the Miombo woodlands of southern Africa. PhytoTrade Africa has facilitated market opportunities for indigenous crops in ways that are based on carefully constructed commercial agreements between farmers and " the local-to-global cosmetic, food, beverage, herbal medicine and pharmaceutical industries." This work has opened up significant livelihood opportunities for otherwise marginalized rural communities. A critical ingredient in its success has been the establishment of strong and viable trade associations at the local level. It is these kinds of initiatives, in addition to the development of legal frameworks that protect farmers' rights, that are needed to ensure equity in the commercialization of indigenous crops.

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THE COP 30X30 BIODIVERSITY TARGETS AND AGRICULTURE

The Global Deal for Nature (GDN), also known as "30x30", was announced at the COP 15 summit in Montreal, Canada, in December 2022, urging nations to commit to a number of global targets and goals relating to reversing the Earth's currently rapid loss of biodiversity. All regions represented in this report contain large areas – and arguably the majority of – areas that are considered global biodiversity hotspots (Conservation International, 2019).

These regions are also central within global efforts to regenerate ecosystem health and begin halting biodiversity loss and mitigate runaway climate change (Strassburg et al., 2020). There was also a recognition in the report that ensuring ecological integrity is paramount to enable all other types of social, economic, and political functioning. In asking the question of how regenerative agriculture/agroecology can be scaled *(see Report 1 for how the concept of 'scaling' is conceived of here)* within the regions represented in this report, all of these factors play into the political, social, and economic environments that are determining what the trajectory of agriculture becomes, and ultimately how effective efforts will be in reversing the degenerative path most societies are currently on.

Image: Deforestation for palm oil in Orangutan habitat Image Credit: https://orangutanfoundation.org.au/palm-oil/

Agriculture is intimately linked with loss or gain of biodiversity and ecological health (Benton et al., 2021) depending on the tools, techniques, governance structures, and farming regimes that are used. To effectively consider biodiversity, the concept needs to be approached at multiple levels, including *genetic, species, and ecosystem* levels. These correspond to healthily sized and dynamic gene pools within species, multiple species performing vast arrays of roles across all trophic levels, and variety and connectivity between multiple ecosystems. The industrial agriculture trajectory has historically been a process of simplification – of homogenization and consolidation (Scharper & Cunningham, 2006) – at all these levels, with socially and politically detrimental effects alongside the ecological ones (UNEP, 2020).

Agroecological approaches, however, exemplified by the clear majority of smallholder farmers among the world's estimated 608+ million farms, operate in ways that facilitate and encourage diversification both on and off the farms (Ricciardi et al., 2021), and often at all three levels of biodiversity (the *Wanakaset* farmers in Thailand presented in Report 3 are one example of how this can be done). Where the opposite tendency is true, it is usually economic, political, and infrastructural factors that are restrictive. Indigenous and traditional knowledge and practices have proven especially valuable in their disproportionate ability to steward both general biodiversity (World Bank, 2021) and agro-biodiversity in particular (National Research Council, 1989).

The crops mentioned in this report represent a minuscule selection of species that are and can be cultivated – and potentially brought to markets – within more diversified expressions of agriculture. Many more will have roles to play within broader agroecological and landscape systems.

The uplifting, reclamation, and sharing of *place-sourced* knowledge – including indigenous and traditional knowledge systems – have a key role to play here, alongside scientific research and innovation (see e.g. "Two-Eyed Seeing" and a selection of other indigenous knowledge-science-bridging frameworks in Reid et al., 2020) in service to enabling appropriate levels and kinds of mechanization and use of technology (e.g. in monitoring and verification) to serve the re-diversification of agricultural systems.

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Part 4:

Crop Compendium

NOTE ON THE SELECTION AND ORGANIZATION OF CROPS:

- Types of crops considered: timber, food, fiber, cosmetics, other
- Conditions studied for crop suitability: climate, biome and ecoregion, including altitude and rainfall; fitness to be integrated into a highly diversified cropping system; cultural aspects (for example, use in traditional local cuisines or as homemade medicinal preparations)
- Conditions studied for market opportunities and risks: size of existing markets (export and/or local), analysis of emerging markets and demand; ease of aggregation and transport, potential for value-added processing
- Types of markets considered: Expert, Experimental, Local/Domestic, and Subsistence
- We include a column on average crop yields per hectare, based on FAO statistics. Note that yields are only one dimension to help determine the economic viability of a crop. It does not necessarily indicate number of people nourished

Haiti/Caribbean

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Okra	*Abelmoschus esculentus*	Subtropical - Tropical	4.37				✓					✓	✓	Useful border crop
Maguey	*Agave americana*	Subtropical - Tropical				✓						✓		
Agave	*Agave spp.*	Semi-Arid	1.07 (fiber)	✓		✓	✓		didgeridoos	✓				
Aloe vera	*Aloe vera*	Tropical					✓	✓	medicine	✓				
Purple Amaranth	*Amaranthus cruentus*	Tropical Savanna				✓	✓							Tropical cover crop
Amaranth	*Amaranthus hypochondriacus*	Tropical Savanna				✓	✓			✓		✓	✓	Tropical cover crop
Pineapple	*Ananas comosus*	Subtropical -Tropical		✓			✓			✓		✓	✓	
Soursop	*Annona muricata*	Tropical					✓					✓	✓	
Custard apple	*Annona reticulata*	Subtropical - Tropical					✓					✓	✓	
Peanut	*Arachis hypogaea*	Tropical Savanna	1.65				✓			✓		✓		Tropical cover crop
Breadfruit	*Artocarpus altilis*	Tropical		✓	✓		✓			✓		✓	✓	Significantly high yielding food plant 200 fruits per tree per season). Historically a part of the indigenous Haiti Jardin systems
Jackfruit	*Artocarpus heterophyllus*	Tropical					✓							
Star Fruit	*Averrhoa carambola*	Humid Tropics					✓							Tropical cover crop
Neem tree	*Azadirachta indica*	Subtropical - Tropical					✓		oil, natural pesticide			✓		Combats desertifiation
Pigeon Pea	*Cajanus cajan*	Tropical Savanna	0.86				✓		medicinal, animal feed	✓		✓	✓	Tropical cover crop as well, grown as a subsistence crop in many different climates within the Caribbean
Jack-bean	*Canavalia ensiformis*	Tropical					✓		fodder			✓	✓	The plant is not in large-scale commercial cultivation. The beans are mildly toxic, and copious consumption should be avoided. Boiling will, however, remove toxicity if done properly. Young foliage is also edible. The whole plant is used for fodder
Pimento	*Capsicum annuum*	Temperate - Tropical	17.65	✓			✓			✓		✓	✓	
Chili Hot Pepper	*Capsicum frutescens*	Subtropical - Tropical	17.65	✓			✓			✓		✓		
Malagueta	*Capsicum frutescens 'Malagueta'*	Temperate - Tropical					✓			✓		✓	✓	
Papaya	*Carica papaya*	Humid Tropics	23.72				✓			✓			✓	Tropical cover crop
Ceiba	*Ceiba pentandra*	Tropical		✓		✓	✓		traditional medicine					

Haiti/Caribbean

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Lagos Spinach	*Celosia argentea*	Tropical Savanna					✓					✓	✓	Tropical cover crop
Paradise plum	*Chysobalanus icaco*	Humid Tropics					✓		medicine			✓	✓	Considered edible, grows wild in the Caribbean. Salt tolerant
chickpea	*Cicer arietinum*	Temperate	1.06				✓			✓				Useful border crop. Rarely grown in the tropcis, though the DR is (minimal) participant in the global market. Requires lengths of cool temeratures, not recommended for the Caribbean
Key lime	*Citrus aurantiifolia*	Subtropical - Tropical	12.17	✓			✓			✓			✓	Historically a part of the indigenous Haiti Jardin systems
Lime	*Citrus aurantiifolia*	Subtropical - Tropical	12.17	✓			✓			✓			✓	Historically a part of the indigenous Haiti Jardin systems
Sweet orange	*Citrus x sinensis*	Subtropical - Tropical	19.21	✓	✓		✓		perfume	✓			✓	Historically a part of the indigenous Haiti Jardin systems. Primary export crop of the Caribbean
Coconut	*Cocos nucifera*	Humid Tropics	5.42	✓	✓	✓	✓			✓			✓	Primary export crop of the Caribbean. Tropical cover crop as well
Coffee	*Coffea arabica*	Humid Tropics	0.76	✓			✓			✓		✓	✓	Historically a part of the indigenous Haiti Jardin systems. In Haiti, gang hawking makes it difficult to transport green coffee for export. Thus, local markets are more promising (and are currently strong). Primary export crop of the Caribbean
Coffee	*Coffea rubusta*	Humid Tropics	0.76	✓			✓			✓		✓	✓	Historically a part of the indigenous Haiti Jardin systems. In Haiti, gang hawking makes it difficult to transport green coffee for export. Thus, local markets are more promising (and are currently strong). Primary export crop of the Caribbean
Taro	*Colocasia esculenta*	Temperate - Tropical	6.91	✓			✓					✓	✓	
Melon	*Cucumis melo*	Subtropical - Tropical	26.56				✓					✓	✓	Useful border crop
Pumpkin/squash	*Cucurbita spp.*	Subtropical - Tropical	15.83	✓			✓				✓	✓	✓	Grown as a subsistence crop in many different climates within the Caribbean
Turmeric	*Curcuma longa*	Temperate - Tropical					✓			✓				
Fonio	*Deigitaria exilis*	Tropical Savanna	0.7438				✓				✓	✓	✓	Tropical cover crop
Yam	*Dioscorea spp.*	Temperate to subtropical	8.65				✓			✓		✓	✓	Grown as a subsistence crop in many different climates within the Caribbean
Oil Palm	*Elaeis guineensis*	Humid Tropics	11.42				✓			✓				Tropical cover crop
Finger Millet	*Eleusine coracana*	Tropical Savanna	0.97				✓					✓	✓	Tropical cover crop
Teff	*Eragrostis tef*	Tropical Savanna					✓							Tropical cover crop
Acai	*Euterpe oleracea*	Warm Temperate - Tropical					✓			✓	✓			

Haiti/Caribbean

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Buckwheat	*Fagopyrum esculentum*	Tropical Savanna	0.94				✓		furniture stuffing (hulls)	✓		✓	✓	Tropical cover crop
Gliricidia	*Gliricidia sepium*	Tropical			✓				fodder, NFT, coppice					
Soybean	*Glycine max*	Humid Tropics	2.87				✓		vegetable oil	✓				Tropical cover crop
Cotton	*Gossypium arboreum*	Subtropical - Tropical	2.24 (unginned)	✓	✓	✓			cotton and cottonseed oil	✓	✓			Historically was a primary export crop of the Caribbean. Has struggled to compete with US exports since the invention of the cotton gin (US grows larger quantities)
Sunflower	*Helianthus annuss*	Temperate - Tropical					✓		oil, animal feed cake	✓		✓	✓	Tropical cover crop l
Sunchoke	*Helianthus tuberosus*	Temperate					✓					✓	✓	
Sweet potato	*Ipomoea batatas*	Subtropical	12	✓			✓			✓		✓	✓	Grown as a subsistence crop in many different climates within the Caribbean
Mango	*Mangifera indica*	Tropical	9.77	✓			✓			✓			✓	
Cassava/Yuca	*Manihot esculenta*	Humid Tropics	10.62	✓			✓		biofuel, laundry starch	✓		✓	✓	Tropical cover crop. The cassava plant gives the third-highest yield of carbohydrates per cultivated area among crop plants, after sugarcane and sugar beets.
Nispero, Sapodilla	*Manilkara zapota*	Tropical					✓					✓	✓	
Moringa	*Moringa oleifera*	Tropical Savanna					✓		medicine,	✓	✓			Tropical cover crop. Has multiple uses and functions: used as alley cropping (biomass production), animal forage, biogas, a cleaning agent, blue dye, fencing, fertilizer, foliar nutrient, green manure, medicine, ornamental planting, bio-pesticide, rope material, etc.
Plantains	*Musa spp.*	Tropical	6.67				✓			✓		✓	✓	
Banana	*Musa spp.*	Tropical	16.65	✓		✓	✓			✓		✓	✓	Historically a part of the indigenous Haiti Jardin systems, grown as a subsistence crop in many different climates within the Caribbean. Primary export crop of the Caribbean
Nutmeg	*Myristica fragans*	Tropical	0.72				✓			✓				
Rambutan	*Nephelium lappaceum*	Humid Tropics					✓				✓	✓	✓	
Tobacco	*Nicotiana tabacum*	Temperate - Tropical	1.88						medicine, cigars/ cigarettes	✓				Useful border crop. Primary export crop of the Caribbean
Rice	*Oryza Sativa*	Humid Tropics	4.76				✓			✓				Tropical cover crop as well, Export market prices are very low, so it is hard for smallholder producion in the Caribbean to compete. Possible to empasize organic rice production, and then trade to places that are willing to pay the premium. Rice is generally a primary export crop of the Caribbean

Haiti/Caribbean

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Pachira nut	*Pachira aquatica*	Tropical					✓					✓	✓	
Jicama	*Pachyrhizus erosus*	Subtropical - Tropical					✓			✓				
Passion fruit	*Passiflora*	Subtropical - Tropical	7.33				✓			✓		✓	✓	
Pearl Millet	*Pennisetum glaucum*	Tropical Savanna					✓					✓	✓	Tropical cover crop as well
Avocado	*Persea americana*	Tropical	8.99	✓			✓			✓		✓	✓	Historically a part of the indigenous Haiti Jardin systems, particularly sensitive to global warming
Bean	*Phaseolus vulgaris*	Temperate - Tropical	0.77				✓			✓		✓	✓	Grown as a subsistence crop in many different climates within the Caribbean. Straw can be used as animal forage
Bean: Black (Turtle)	*Phaseolus vulgaris*	Temperate - Tropical	0.77				✓			✓		✓	✓	Grown as a subsistence crop in many different climates within the Caribbean. Straw can be used as animal forage
Date palm	*Phoenix dactylifera*	Semi-Arid	7.92				✓				✓	✓		
Mexican pinyon pine	*Pinus cembroides*	Semi-Arid					✓			✓		✓	✓	
Sacha inchi	*Plukenetia volubilis*	Humid Tropics					✓							
White carob tree	*Prosopis alba*	Semi-Arid					✓						✓	Seed processed into a flour
Honeypod Mesquite	*Prosopis glandulosa*	Tropical Savanna					✓						✓	Seed processed into a flour
Castor bean	*Ricinus communis*	Tropical	0.92						medicine, biofuel		✓			Useful border crop
Sugarcane	*Saccharum officinarum*	Humid Tropics	70.56				✓		biofuel	✓				Tropical cover crop as well. Primary export crop
Jojoba	*Simmondsia chinensis*	Subtropical - Tropical	0.48						edible oil	✓	✓			
Yacon	*Smallanthus sonchifolius*	Temperate to tropical highlands					✓					✓	✓	
Sorghum	*Sorghum bicolor*	Tropical Savanna	1.5				✓			✓			✓	Useful border crop, Tropical cover crop as well. Reintroduced to Haiti successfully with the guarentee of a secure market
Miracle fruit	*Synsepalum dulcificum*	Humid Tropics					✓		sweetener			✓	✓	A small berry that has a molecule that makes sour foods taste sweet.
Bullet tree	*Terminalia buceras*	Tropical		✓	✓						✓			
Cacao	*Theobroma cacao*	Humid Tropics	0.46	✓			✓			✓			✓	Historically a part of the indigenous Haiti Jardin systems. In Haiti, farmers are growing more cacao since their coffee crops are more vulnerable to climate change risks. Primary export crop of the Caribbean

Haiti/Caribbean

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ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Mexican sunflower	*Tithonia diversifolia*	Subtropical - Tropical							green manure, cover crop				✓	Useful border crop
Vanilla	*Vanilla genus*	Tropical	0.0748	✓			✓			✓	✓			
Moth Bean	*Vigna aconitifolia*	Tropical Savanna					✓					✓	✓	Tropical cover crop as well
Rice Bean	*Vigna unbellata*	Tropical					✓					✓	✓	Tropical cover crop as well
Bean: Cowpea (black eyed pea)	*Vigna Unguiculata*	Tropical Savanna	0.6				✓			✓		✓	✓	Useful border crop, tropical cover crop as well. Drought Tolerant
Mung Bean	*Vinga radiata*	Humid Tropics	0.77				✓					✓	✓	Tropical cover crop
Yautia	*Xanthosoma sagittifolium*	Subtropical to tropical	12.35	✓			✓					✓	✓	
Corn	*Zea mays*	Humid Tropics	5.88				✓		biofuel, animal feed	✓		✓	✓	Useful border crop, tropical cover crop as well, grown as a subsistence crop in many different climates within the Caribbean. Strong market in Haiti.
Ginger	*Zingiber officinale*	Tropical	10.88				✓		medicinal	✓		✓	✓	
Akee	*Blighia sapida*	Tropical					✓					✓	✓	Related to Litchi

Ecuador/South America

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Okra	*Abelmoschus esculentus*	Subtropical - Tropical	4.4				✓			✓		✓	✓	Useful border crop
Macauba palm	*Acrocomia aculeata*	Tropical Savanna		✓					biodiesel fuel, wine		✓	✓		Potential for smallholders for biodiesel production
Borojo	*Alibertia patinoi*	Humid Tropics		✓			✓		medicine, wine, jam		✓	✓	✓	Borojo, also found in Ecuadorian Esmeraldas. Borojo has high levels of protein, ascorbic acid, calcium and iron and very high levels of phosphorus. High levels of novel polyphenols
Amaranth	*Amaranthus caudatus*	Temperate - Tropical	2.5	✓		✓	✓			✓		✓	✓	Tropical cover crop as well
Cashew Nut	*Anacardium occidentale*	Tropical Savanna - Semi-Arid	1.6	✓	✓	✓				✓		✓	✓	Highly nutrious nut, various trace minerals, drought proof
Pineapple	*Ananas comosus*	Subtropical - Tropical	23.0	✓			✓			✓		✓		Commercially grown in vast monocultures
Cherimoya	*Annona cherimola*	Subtropical - Tropical		✓			✓						✓	The plant grows at high altitudes in the Tropics, where the weather is colder
Soursop	*Annona muricata*	Subtropical - Tropical		✓			✓					✓	✓	Guanabana, national fruit of Ecuador
Sugar Apple	*Annona squamosa*	Subtropical - Tropical		✓		✓							✓	Tolerates tropical lowlands, popular at local markets
Peanut	*Arachis hypogaea*	Warm Temperate - Tropical	2.5	✓			✓			✓		✓	✓	Tropical cover crop as well
Sugar Palm	*Arenga pinnata*	Tropical				✓	✓	✓				✓	✓	Sap collected for sugar; also starch, fibers, leaves for basketry
Arracacha	*Arracacia xanthorrhiza*	Warm Temperate		✓			✓					✓	✓	Andean Highland crop grown between 1300-3300m. Root boiled, baked, soups, stews, fried, puddings, baby foods / Kawi 42 2
Breadfruit	*Artocarpus altilis*	Tropical	16.0		✓		✓			✓		✓	✓	Significantly high yielding food plant 200 fruits per tree per season). Historically a part of the indigenous Haiti Jardin systems
Breadnut	*Artocarpus camansi*	Tropical					✓					✓	✓	Balanced carbohydrate
Jackfruit	*Artocarpus heterophyllus*	Humid Tropics					✓					✓	✓	From Asia, high yielding tree
Coquillo palm	*Astrocaryum alatum*	Tropical					✓						✓	Palm with edible nuts, grows in swampy areas
Tucuma palm	*Astrocaryum vulgare*	Tropical Savanna	4.8	✓					biofuel		✓			Palm ; Secondary forest, potential substitute for Oil Palm
Maripa palm	*Attalea maripa*	Humid Tropics	2.0	✓		✓	✓	✓	medicine		✓	✓	✓	Palm; palm oil, historically important to indigenous peoples
Babassu palm	*Attalea speciosa*	Humid Tropics	2.0	✓		✓	✓	✓	medicine, fiber, oil, butter, feed cake, biofuel	✓	✓	✓	✓	Palm; palm oil, multi-use for indigenous peoples, high value oil for cosmetics
Star fruit	*Averrhoa carambola*	Humid Tropics					✓					✓	✓	Tropical cover crop as well

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ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Peach palm	*Bactris gasipaes*	Humid Tropics		✓			✓				✓	✓	✓	Chonta. Fast growing, the most important domesticated palm species of the Neotropics, peach palm is found in agroforestry systems
Brazil nut	*Bertholletia excelsa*	Tropical		✓			✓			✓		✓	✓	Difficult to cultivate, mainly harvested in wild
Ramon	*Brosimum alicastrum*	Tropical		✓			✓					✓	✓	Staple of Mayans, soil restoration, high ecological calue
Pigeon Pea	*Cajanus cajan*	Tropical Savanna					✓			✓		✓	✓	Tropical cover crop as well, grown as a subsistence crop in many different climates within the Caribbean
Capriona	*Calycophyllum spruceanum*	Humid Tropics		✓	✓				✓	✓	✓	✓	✓	Fast growing timber
Ylang-Ylang	*Cananga odorata*	Tropical							essential oil	✓				Non-native fast growing tree, highly prized essential oil
Achira	*Canna indica*	Warm Temperate		✓			✓					✓	✓	Andean Highland crop grown between 1000-3300 Root Baked, boiled, indstrial starch / Flour 51 16
Capsicum	*Capsicum annuum*	Warm Temperate -Tropical		✓			✓			✓		✓	✓	Aji, native to Andes, widely cultivated, ubiquitous at local markets
Hot Pepper	*Capsicum frutescens*	Warm Temperate -Tropical	17.7	✓			✓			✓		✓		
Papaya	*Carica papaya*	Humid Tropics	23.7	✓			✓			✓				Tropical cover crop as well
Piquia	*Caryocar brasiliense*	Tropical Savanna		✓			✓		✓	✓	✓	✓	✓	Multipurpose food crop, ecologically under strain and important for Cerrado
Cacay	*Caryodendron orinocense*	Humid Tropics		✓			✓				✓	✓	✓	Wachanso
Tornillo	*Cedrelinga catenaeformis*	Tropical		✓	✓					✓	✓	✓	✓	NFT, Fast growing timber
Ceiba	*Ceiba pentandra*	Tropical		✓		✓	✓		traditional medicine, oil		✓	✓		Fiber, difficult to Spin
Mandacaru	*Cereus jamacaru*	Semi-Arid		✓			✓					✓	✓	Cactus native to Caatinga
Kaniwa	*Chenopodium pallidicaule*	Warm Temperate		✓			✓				✓	✓	✓	Andes, high potential crop, nutrient-dense, low inputs
Quinoa	*Chenopodium quinoa*	Warm Temperate		✓			✓			✓		✓	✓	Ubiquitous seed grain from the Andes, highly nutritious
Chickpea	*Cicer arietinum*	Warm Temperate - Tropical	1.1				✓					✓	✓	Winter crop in tropics
Cinnamon	*Cinnamomum verum*	Tropical					✓		bark	✓				From Asia, small production in South America
Watermelon	*Citrullus lanatus*	Subtropical - Tropical					✓			✓		✓	✓	Popular cash crop
Tahiti Lime	*Citrus × latifolia*	Subtropical - Tropical	12.2				✓			✓		✓		Cash crop

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Key lime	*Citrus aurantifolia*	Subtropical - Tropical	12.2				✓			✓		✓	✓	Valued citrus for export
Tangerine	*Citrus reticulata*	Subtropical - Tropical	19.2				✓			✓		✓	✓	Small citrus, more perishable than other citrus, prized in domestic markets
Grapefruit	*Citrus x paradisi*	Subtropical - Tropical	5.6				✓					✓	✓	Toronja
Sweet orange	*Citrus x sinensis*	Subtropical - Tropical	0.8				✓			✓			✓	Ubiquitous crop, for juice and whole fruit, large export market
Coconut	*Cocos nucifera*	Humid Tropics	0.8				✓			✓		✓	✓	Various uses, high value oil
Coffee	*Coffea arabica*	Humid Tropics	6.9				✓			✓		✓	✓	High value export crop, competitive, grows at altitude
Coffee	*Coffea rubusta*	Humid Tropics					✓			✓		✓	✓	Grows in tropical lowlands and in full sun, export crop
Taro	*Colocasia esculenta*	Tropical										✓	✓	Papa china, one of the main starch tubers
Carnauba palm	*Copernicia prunifera*	Tropical Savanna - Semi-Arid		✓	✓	✓	✓		wax, jelly, fodder, seed oil, coffee substitute	✓		✓	✓	Caatinga 'Tree of Life' multifunctional, drought tolerant, grows by rivers. Prized wax. Cornerstone species of Caatinga
Milktree	*Couma utilis*	Humid Tropics		✓	✓		✓		flavoring, caulking, cabinetry		✓	✓		Multi-use tree, fruit, latex, timber
Jicaro	*Crescentia cujete*	Humid Tropics	15.8	✓					✓			✓	✓	Calabash used in bowls, canteens, utensils
Sangre de Dragon	*Croton lechleri*	Humid Tropics		✓					medicine				✓	Sangre de Drago
Pumpkin	*Cucurbita moschata*	Warm Temperate -Tropical					✓					✓	✓	grown as a subsistence crop in many different climates within the Caribbean
Guacharaco	*Cupania americana*	Tropical	8.7	✓	✓		✓					✓	✓	The sweet, chestnut-like seeds are used as a food
Turmeric	*Curcuma longa*	Warm Temperate -Tropical					✓			✓				Ubiquitous export crop
Yam	*Dioscorea trifida*	Humid Tropics	11.4				✓			✓		✓	✓	grown as a subsistence crop in many different climates within the Caribbean
Oil Palm	*Elaeis guineensis*	Humid Tropics					✓			✓				Tropical cover crop as well
Cardamom	*Elettaria cardamomum*	Humid Tropics	120 - 210 KG per tree			✓				✓		✓		Export spice from Asia, used in local cuisine
Sacha culantro	*Eryngium foetidum*	Tropical		✓			✓					✓	✓	HIgh in trace minerals

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ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Poroton	*Erythrina edulis*	Warm Temperate - Tropical		✓			✓		NFT, fodder				✓	Cloud Forest Organics, Chachafruto
Coca	*Erythroxylum coca*	Tropical		✓					stimulant			✓	✓	Stimulant for coca chewing, prized at local markets
Pitomba	*Eugenia luschnathiana*	Semi-Arid		✓			✓					✓	✓	Caatinga
Araza	*Eugenia stipitata*	Humid Tropics		✓			✓				✓	✓	✓	Araza, Kichwa, Amazon
Surinam Cherry	*Eugenia uniflora*	Tropical		✓			✓		medicine		✓	✓	✓	Many pharmacological applications
Açai	*Euterpe oleracea*	Tropical		✓			✓			✓	✓			
Fique	*Furcraea andina*	Tropical		✓		✓					✓			Forgotton Fiber
Gliricidia	*Gliricidia sepium*	Tropical		✓										
Egyptian Cotton	*Gossypium barbadense*	Warm Temperate -Tropical	2.0	✓		✓				✓	✓	✓		Long staple cotton, 5% of world production, native to Ecuador and Peru
Upland Cotton	*Gossypium hirsutum*	Subtropical - Tropical	2.0			✓			cotton and cottonseed oil	✓	✓			Short staple cotton, 90% of world production
Pitón	*Grias neuberthii*	Tropical		✓			✓					✓	✓	
Bolaina	*Guazuma crinita*	Tropical		✓	✓						✓	✓	✓	High Potential Timber for Smallholders
Mangaba	*Hancornia speciosa*	Semi-Arid		✓	✓		✓				✓	✓	✓	Native to Caatinga, edible wild fruit, latex for rubber
Sunflower	*Helianthus annuus*	Temperate					✓		edible oil			✓		Important edible (cooking) oil, grown in temperate climate
Rubber	*Hevea brasiliensis*	Humid Tropics	1.2	✓			✓			✓				Famous rubber tree, made from tapped latex
Guayusa	*Ilex guayusa*	Humid Tropics		✓			✓		stimulant		✓	✓	✓	Stimulant Tea
Ice Cream Bean	*Inga edulis*	Tropical		✓			✓		NFT, fodder				✓	
Sweet potato	*Ipomoea batatas*	Subtropical - Tropical	12.0	✓			✓			✓		✓	✓	grown as a subsistence crop in many different climates within the Caribbean
Jatropha	*Jatropha curcas*	Semi-Arid							biofuel	✓	✓			High oil producing seed suited for biofuel production
Andean Walnut	*Juglans neotropica*	Warm Temperate		✓			✓					✓	✓	Nogal, endangered in Andean cloud forests
Coco de Mono	*Lecythis ollaria*	Tropical		✓			✓				✓	✓	✓	Coco de Mono It is in the same family as the Brazil nut tree (*Bertholletia excelsa)* and has a similar fruit.
Paradise Nut	*Lecythis zabucajo*	Humid Tropics		✓			✓				✓	✓	✓	Important Amazonian staple, good oil

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ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Lentils	*Lens culinaria*	Subtropical - Tropical					✓			✓		✓	✓	Common staple food brought to South America
Piassava palm	*Leopoldinia piassaba*	Tropical		✓		✓	✓					✓	✓	Palm; Water resistant fiber
Maca	*Lepidium meyenii*	Temperate		✓			✓				✓	✓	✓	Andean Highland crop grown between 3900-4500 m; salads / liquor, juice
Macadamia	*Macadamia macrophylla*	Tropical					✓			✓		✓	✓	Nutritious nut, popular for export
Acerola	*Malpighia emarginata*	Subtropical - Tropical		✓			✓		medicine	✓			✓	Superfood from Brazil, high vitamin C and phytonutrients
Mango	*Mangifera indica*	Tropical					✓			✓		✓	✓	Ubiquitous fruit, exported worldwide
Cassava/Yuca	*Manihot esculenta*	Humid Tropics	9.8	✓			✓			✓		✓	✓	The cassava plant gives the third-highest yield of carbohydrates per cultivated area among crop plants, after sugarcane and sugar beets.
Sapodilla	*Manilkara zapota*	Tropical	10.6	✓			✓					✓	✓	Edible fruit Chicle from bark is used for chewing gum
Buriti palm	*Mauritia flexuosa*	Humid Tropics		✓		✓	✓		oil			✓	✓	Multi-use edible sweet fruit, nutritive oil
Mauka	*Mirabilis expansa*	Temperate		✓			✓					✓	✓	Andean Highland crop grown between 2300-3200m, Root Boiled, stews, soups, fried, puddings
Moringa	*Moringa oleifera*	Tropical Savanna					✓			✓	✓		✓	Tropical cover crop as well
Mulberry	*Morus nigra*	Temperate - Tropical	6.0				✓			✓		✓	✓	Edible young leaves, perishable fruit
Banana/ Plantain	*Musa spp.*	Humid Tropics				✓	✓			✓		✓	✓	Historically a part of the indigenous Haiti Jardin systems, grown as a subsistence crop in many different climates within the Caribbean
Abaca	*Musa textilis*	Tropical	16.7			✓					✓	✓		Strong natural fibers, developed for export
Arrayan	*Myrcianthes rhopaloides*	Warm Temperate		✓			✓					✓	✓	Edible fruit
Camu-camu	*Myrciaria dubia*	Humid Tropics		✓			✓				✓	✓	✓	Exporting to Japan, endangered in the wild, commercialisation encouraged
Nutmeg	*Myristica fragans*	Tropical	12.0				✓			✓				Grown for nutmeg spice
Rambutan	*Nephelium lappaceum*	Tropical	0.7				✓					✓	✓	It is also produced in Ecuador where it is known as achotillo, very perishable
Tobacco	*Nicotiana tabacum*	Temperate - Tropical							medicine, cigars/ cigarettes	✓				Useful border crop
Ungurahua palm	*Oenocarpus bataua*	Humid Tropics	1.9	✓			✓				✓	✓	✓	The tree produces edible fruits rich in high-quality oil.
Prickly Pear	*Opuntia ficus-indica*	Semi-Arid					✓					✓	✓	Cactus produces edible fruits, drought tolerant
Rice	*Oryza sativa*	Subtropical -Tropical					✓			✓		✓	✓	Export market prices are very low, so it is hard for smallholder producion to compete.
Oca	*Oxalis tuberosa*	Temperate	4.8	✓			✓					✓	✓	Andean Highland crop grown between 3000-4000 Tuber boiled, baked

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Malabar Chestnut	*Pachira aquatica*	Tropical					✓						✓	Edible nut, wetland tree
Saba nut	*Pachira glabra*	Tropical					✓		nut for food and oil			✓	✓	The seeds are rich in oil and contain 16% protein and 40–50% fat. The seeds taste similar to peanuts and are typically boiled or roasted. The young leaves and flowers are also edible
Amazonian yam bean	*Pachyrhizus tuberosus*	Tropical		✓			✓					✓	✓	Native to Mexico, nutritious tuber, also known as Jicama
Andean yam bean	*Pachyrhizus ahipa*	Temperate	28.0	✓			✓					✓	✓	Ahipa, Andean Highland crop grown between 1500-3000 m root baked, salad, juice
Maracuja do mato	*Passiflora galbana*	Semi-Arid		✓			✓					✓	✓	Native to Caatinga
Granadilla	*Passiflora ligularis*	Warm Temperate		✓			✓						✓	Granadilla
Brazilwood	*Paubrasilia echinata*	Tropical Savanna		✓	✓				✓					Endangered
Avocado	*Persea americana*	Tropical	9.0	✓			✓			✓			✓	Historically a part of the indigenous Haiti Jardin systems, particularly sensitive to global warming
Bean	*Phaseolus spp.*	Warm Temperate -Tropical	0.8				✓			✓		✓	✓	grown as a subsistence crop in many different climates within the Caribbean
Cape Gooseberry	*Physalis peruviana*	Warm Temperate		✓			✓			✓		✓	✓	Uvilla
Ivory nut palm	*Phytelephas spp.*	Humid Tropics							vegetal Ivory		✓			Vegetal Ivory
Xique-xique	*Pilosocereus gounellei*	Semi-Arid		✓			✓					✓	✓	Cactus, subsistence food
Black pepper	*Piper nigrum*	Tropical	2.2				✓			✓		✓		Vining, high value export crop
Jaboticaba	*Plinia cauliflora*	Semi-Arid					✓					✓	✓	Slow growing, berries on trunk, juice, jams. Brazil native
Sacha Inchi	*Plukenetia volubilis*	Humid Tropics		✓			✓		edible oil		✓	✓	✓	Highly nutritious, produces a prized oil, high potential crop
Amazon Grape	*Pourouma cecropiifolia*	Humid Tropics		✓			✓					✓	✓	Uvilla de Arbol
Abio	*Pouteria caimito*	Tropical		✓			✓					✓	✓	Abiu fruit is a significant source of calcium, phosphorus, vitamin A, and vitamin C.
Lucuma	*Pouteria lucuma*	Warm Temperate		✓			✓		food supplement	✓	✓	✓	✓	Grows in cloud forests, also known as Togmilla
Algarrobo blanco	*Prosopis alba*	Semi-Arid					✓						✓	Seeds can be turned into a flour for human consumption
Sour Guava	*Psidium acidum*	Subtropical - Tropical		✓			✓					✓	✓	Guayaba, native to Peru and Ecuador, less sweet
Apple Guava	*Psidium guajava*	Subtropical - Tropical		✓			✓			✓		✓	✓	Guayaba, more sweet, commerically grown as well
Sugarcane	*Saccharum officinarum*	Humid Tropics	70.6				✓		refined sugar	✓				Tropical cover crop as well

Ecuador/South America

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Chia	*Salvia hispanica*	Warm Temperate -Tropical	2.3	✓			✓			✓				Pseudo-cereal, grown for seed, high in omega fats, superfood
Monkeypod	*Samanea saman*	Tropical			✓		✓		medicine				✓	Fruit pulp can be made into a beverage that tastes like lemons, wood is used for carving and making furniture
Pitaya	*Selenicereus undatus*	Tropical Savanna - Semi-Arid					✓					✓	✓	Fruit from cactus, also known as Dragon fruit
Yacon	*Smallanthus sonchifolius*	Temperate		✓			✓				✓	✓	✓	2000-2900 rhizeome syrup, flour, chips, juice, antihyperglycemic properties
Tomate de Arbol	*Solanum betaceum*	Warm Temperate		✓			✓			✓		✓	✓	Native to Andes, nutritious fruit, used world wide
Naranjilla	*Solanum quitoense*	Tropical		✓			✓					✓	✓	The juice of the naranjilla is green and is often used as a juice or for a drink called lulada
Cocona	*Solanum sessiliflorum*	Warm Temperate		✓			✓						✓	Cloud forest
Potato	*Solanum tuberosum*	Temperate	20.7	✓			✓					✓	✓	Native to Andes, countless varieties, important staple crop
Caja	*Spondias mombin*	Semi-Arid		✓			✓					✓	✓	Native to Caatinga
Umbu	*Spondias tuberosa*	Semi-Arid		✓			✓					✓	✓	Native to Caatinga
Mahogany	*Swietenia macrophylla*	Humid Tropics		✓	✓				✓	✓		✓		Superior quality wood, some medicinal uses
Licuri	*Syagrus coronata*	Semi-Arid		✓			✓					✓	✓	Native to Brazil, pulp is edible, oil from seed, important for animals as well
Cloves	*Syzygium aromaticum*	Tropical				✓		✓	pesticide, medicine	✓				Famous spice, mainly grown in Asia, export potential
Bullet tree	*Terminalia buceras*	Tropical		✓	✓					✓			✓	Heavy timber
Patas Muyo	*Theobroma bicolor*	Tropical		✓			✓				✓		✓	Similar to cacao, seeds are edible, rich in protein and fiber also high in Omega 9 and contain caffeine
Cacao	*Theobroma cacao*	Tropical	0.5	✓			✓			✓			✓	The famous ingredient for making chocolate
Cupuacu	*Theobroma grandiflorum*	Tropical		✓			✓	✓	seed oil		✓	✓		Brazilians either eat it raw or use it in making sweets
Mexican sunflower	*Tithonia diversifolia*	Subtropical - Tropical							green manure, support species				✓	Useful border crop
Mashua	*Tropaeolum tuberosum*	Temperate		✓			✓				✓	✓	✓	Andean Highland crop grown between 3000-4000; Tuber boiled, baked / Tayacha 216 4
Ulluco	*Ullucus tuberosus*	Temperate		✓			✓					✓	✓	Grows at altitude (3000-4000m), eaten as tuber soups, stews, salads
Vanilla	*Vanilla planifolia*	Tropical	0.1				✓			✓				Ubiquitous export crop, highly prized
Mountain Papaya	*Vasconcellea pubescens*	Warm Temperate		✓			✓						✓	Chamburo

Ecuador/South America

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Fava bean	*Vicia faba*	Temperate - Tropical					✓					✓	✓	Drought tolerant legume, edible, animal fodder, green manure, cover crop
Cowpea	*Vigna unguiculata*	Tropical	0.6				✓					✓	✓	Edible support species, legume, nitrogen fixing
Cumala	*Virola elongata*	Tropical		✓			✓		medicine				✓	Seeds are rich in oil, used for candles and soap, hallucinogen
Virola nut	*Virola sebifera*	Tropical		✓					medicine, oil, halluc-inogen					Indigenous to Amazon, used as hallucinogen, as well as for the oil from its nut.
Tania	*Xanthosoma sagittifolium*	Subtropical - Tropical	12.4	✓			✓					✓	✓	Important staple food, starchy tuber
Corn	*Zea mays*	Warm Temperate -Tropical	8.0	✓			✓		oil, biofuel	✓		✓	✓	Ubiquitous crop from Mexico, countless varieties, important staple, made into flour, and edible oil. Commercial use for corn ethanol, animal feed and other maize products, such as corn starch and corn syrup
Ginger	*Zingiber officinale*	Warm Temperate -Tropical	10.9				✓			✓				Easily integrated in the understory, high value root crop

Thailand/Southeast Asia

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Abaca	*Musa textilis*	humid tropics	0.76			✓				✓	✓	✓		Relative of banana, producing highly durable, long and versatile natural fiber. Many traditional uses including ropes and baskets; innovative use in apparel and footwear.
Acacia, Brown Salwood	*Acacia mangium*	Tropics/ subtropics			✓				paper pulp	✓				N-fixer. Fast-growing tree. Can be used to rehabilitate degraded or contaminated soils.
Bamboo	*Bambusa multiplex*	Humid tropics/ subtropics			✓	✓	✓							
Bamboo fungus	*Phallus indusiatus*	Tropics					✓	✓	medicine	✓	✓	✓		Bioactive properties, potential for pharmaceutical uses
Banana	*Musa spp.*	Humid tropics	16.65				✓					✓	✓	
Betel	*Piper betle*	Tropics					✓		stimulant/ ceremony	✓		✓		
Bitter gourd	*Momordica charantia*	Tropics		✓			✓				✓	✓	✓	promising health effects, including reducing the risk of diabetes
Black pepper	*Piper nigrum*	Humid tropics	2.24				✓			✓		✓		
Breadfruit	*Artocarpus altilis*	Humid tropics		✓			✓					✓	✓	Staple food in the tropics
Breadnut	*Artocarpus camansi*	Humid tropics					✓					✓	✓	Balanced carbohydrate
Burmese grapes	*Baccaurea ramiflora*	Humid tropics					✓		medicinal			✓		a popular fruit locally, with good nutritional profile and medicinal properties
Cacao	*Theobroma cacao*	Humid tropics	0.46				✓	✓		✓				great agroforestry potential; more adaptive to climate change than coffee
Candlenut	*Aleurites moluccanus*	Humid tropics					✓	✓	varnishes, inks		✓			The nut can be used as such or extracted for oil for cooking or cosmetics purposes.
Cardamom	*Elettaria cardamomum*	Humid tropics	0.72				✓			✓		✓		
Cashew nut	*Anacardium occidentale*	Semi-arid to humid tropics	1.59		✓		✓			✓		✓		Robust existing export market
Cassava	*Manihot esculenta*	Tropics/ Subtropics	10.6167				✓		starch, biofuel	✓		✓		Excellent subsistence and food security crop; export potential especially as value-added products (chips, tapioca starch etc.) Tapioca root resin can be used to manufacture biodegradable bags as a viable plastic substitute
Castor bean	*Ricinus communis*	Arid to humid tropics/ subtropics	0.92					✓	lots of uses	✓		✓		Castor oil has many uses in medicine and other applications
Champak	*Michelia champaca*	Tropics/ subtropics			✓				perfumes	✓				Valuable timber. Flowers used for perfume and fragrant oils. Cultural relevance as a tree of enlightenment in Buddhism.
Chaphlu	*Piper sarmentosum*	Tropics					✓		medicine			✓		Leaves are used in traditional Southeast Asian cuisine and also have medicinal uses.
Chempedak (Cempedak)	*Artocarpus integer*	Humid tropics					✓					✓		Similar to its relatives breadfruit and jackfruit, can be eaten as a fruit or vegetable and has many applications in Southeast Asian cuisines
Chili Pepper	*Capsicum annuum*	Semi-arid to humid tropics	17.65				✓			✓		✓	✓	

Thailand/Southeast Asia

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Cinnamon	*Cinnamomum verum*	Humid tropics to subtropics	0.90				✓			✓				
Cloves	*Syzygium aromaticum*	Humid tropics	0.28				✓	✓	pesticide, medicine	✓				
Coconut	*Cocos nucifera*	Humid tropics	5.63				✓	✓		✓		✓	✓	Highly productive, good fit for agroforestry systems because its canopy doesn't cast a large shade. Coconuts have endless uses, from coconut water and milk to flours, chips, etc.
Coffee	*Coffea arabica, Coffea robusta*	Humid tropics	0.76				✓			✓				Excellent agroforestry crop as it tolerates shade.
Dogfruit, Djenkol	*Archidendron pauciflorum*	Humid tropics and highlands					✓		medicinal, dye		✓	✓		The beans are mildly toxic and need to be prepared; traded only in local markets.
Durian	*Durio zibethinus*	Humid tropics					✓			✓		✓	✓	Currently a lot of market demand; however, often grown using a lot of pesticides.
Elephant foot yam	*Amorphophallus paeoniifolius*	Tropics		✓			✓		medicinal			✓	✓	High production potential and popularity as a vegetable in various Asian cuisines.
Fig	*Ficus carica*	Semi-arid to humid tropics and subtropics	4.5				✓			✓		✓	✓	Native fig varieties do not produce edible fruit, but Middle Eastern figs could be grown commercially in Southeast Asia. Such commercial production already exists in Malaysia.
Galip nut	*Canarium indicum*	Humid tropics		✓	✓		✓	✓			✓			Kernels can be eaten as such or pressed for oil. Many uses, including as timber, or animal feed.
Ginger	*Zingiber officinale*	Tropics to subtropics	10.88				✓			✓		✓		
Gnemon	*Gnetum gnemon*	Humid tropics					✓		medicinal potential		✓			nuts are eaten boiled, roasted, or raw. Intereresting phytochemical properties
Ground nut	*Arachis hypogaea*	Semi-arid to humid tropics and subtropics	1.65				✓			✓		✓		
Gutta percha	*Palaquium gutta*	Humid tropics			✓			✓	latex	✓	✓			used in dental fillings
Hemp	*Cannabis sativa*	Humid temperate to tropical				✓	✓		lots of uses	✓		✓		Cultivated for food, fiber, and pharmaceuticals
Indigo	*Indigofera tinctoria*	Tropical to warm temperate							dye	✓		✓		The market for natural dyes is likely to grow as the negative impacts of synthetic dyes become better known. Indigo is one of the most highly-valued, vibrant and lightfast natural dyes.
Jackfruit (jack tree)	*Artocarpus heterophyllus*	Humid tropics		✓	✓		✓			✓		✓		In addition to local markets, there's a growing export market especially for jackfruit-based meat alternatives
June Plum, Golden Apple, Makok Farang	*Spondias cytherea*	Tropics					✓			✓		✓	✓	Edible fruit and leaves
Kangkong	*Ipomoea aquatica Forsk*	Tropics		✓			✓							Considered to have potential benefits in reducing risk of diabetes
Kapok	*Ceiba pentandra*	Humid tropics	2.27			✓			paper-making	✓		✓		Kapok fibre is used locally for stuffing pillows and mattresses, the flowers also provide abundant nectar for bees

Thailand/Southeast Asia

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Kava	*Piper methysticum*	Tropics to subtropics		✓			✓		lots of uses					Used in South Pacific islands as a traditional ceremonial beverage due to its mildly sedative effects; a growing international market.
Konjac	*Amorphophallus konjac*	Tropics							trad. medicine	✓	✓	✓		Flour extracted from konjac is used in East Asian cuisine to make noodles, tofu and snacks. Also has medicinal properties. has been introduced on a relatively small scale into the US and Europe, as a food additive and a dietary supplement.
Kratom	*Mitragyna speciosa*	Tropics					✓				✓			Medicinal potential, but the efficacy and safety of kratom are as of yet unclear. More research needed.
Kwini	*Mangifera odorata*	Humid tropics					✓		traditional medicine		✓	✓		Nutritious, sour-tasting mango relative, good in chutneys
Langsat, Longkong	*Lansium parasiticum*	Tropics to subtropics					✓				✓	✓		Prefers shade, good in agroforestry
Lemongrass	*Cymbopogon*	Tropics to subtropics	12.17				✓	✓		✓		✓	✓	Important culinary ingredient regionally
Lime	*Citrus spp.*	Tropics					✓			✓		✓		
Long pepper	*Piper longum*	Tropics					✓		medicine			✓		Today a very rare ingredient in European cuisines but used in Africa and Asia
Longan	*Dimocarpus longan*	Humid tropics					✓				✓	✓		Fruit similar to Litchi; mostly regional uses
Mahogany, Siamese Neem Tree, Cigar Box Cedar	*Swietenia macrophylla*	Tropics			✓				medicinal potential	✓		✓		Seeds have pharmaceutical potential; However, there are reports of liver injury
Malabar spinach	*Basella alba*	Tropical to subtropical semi-arid	9.77	✓			✓					✓	✓	
Mango	*Mangifera indica*	Humid tropics	9.77				✓	✓		✓		✓		
Mangosteen (Cowa)	*Garcinia cowa*	Humid tropics	9.77				✓		medicine, dyes, resins		✓	✓		
Mangosteen (purple)	*Garcinia mangostana*	Tropics					✓		medicine, dyes		✓	✓		Has a cap which makes it hard to get rid of insects, necessitating fumigation.
Monkey Jack	*Artocarpus lacucha*	Subtropical to tropical semi-arid to humid			✓		✓	✓	medicinal		✓	✓		Oxyresveratrol can be extracted from the heartwood.
Moringa	*Moringa oleifera*	Tropics					✓	✓		✓		✓		Edible (highly nutritious) leaves, seeds and fruit pods
Munpla/Tembusu	*Fagraea fragrans*	Subtropical to tropical arid to humid			✓					✓		✓		Produces very hard wood excellent for chopping boards.
Neem Tree	*Azadirachta indica*	Humid tropics	0.72					✓	pesticide	✓		✓		
Nutmeg	*Myristica genus*	Humid tropics	11.42		✓		✓			✓		✓		
Oil palm	*Elaeis guineensis*	Tropics												
Pandan	*Pandanus amartllifolius*	Tropics	23.72				✓		wrap food for cooking	✓		✓		Use to give fragrance and green color to desserts/ drinks- grows in wet (swampy) areas of the land

Thailand/Southeast Asia

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Papaya	*Carica papaya*	Tropics	23.72				✓			✓		✓		
Passion fruit	*Passiflora*	Tropics	7.33				✓			✓		✓		
Pigeon pea	*Cajanus cajan*	Semi-arid tropics	0.86				✓			✓		✓		World production of pigeon peas is estimated at 4.49 million tons. A drought-resistant, nutritious alternative crop. Not as typical in SE Asian cuisine as in Africa and South America
Pili nut	*Canarium ovatum*	Tropics					✓				✓			Native to Philippines. There is almost no commercial planting of this crop; fruits are collected from natural stands in the mountains near these provinces.
Pineapple	*Ananas comosus*	Humid tropics	23.01				✓			✓		✓		
Plantain	*Musa spp.*	Humid tropics	6.67				✓							
Rambutan	*Nephelium lappaceum*	Tropics		✓			✓			✓		✓		Thailand is a major exporter of rambutan. The fruit has a short shelf life.
Ramie	*Urticaceae boehmeria*	Temperate to tropical	2.17			✓				✓	✓			Despite its strength, ramie has had limited acceptance for textile use. The fiber's extraction and cleaning are expensive, chiefly because of the several steps—involving scraping, pounding, heating, washing, or exposure to chemicals.
Rattan Palm	*Calamus caesius*	Tropics			✓	✓								Producing wickerwork furniture, baskets, canes, woven mats, cordage, and other handicrafts
Rice	*Oryza sativa*	Subtropical to tropical	4.76				✓			✓		✓	✓	
Rubber	*Hevea brasiliensis*	Humid tropics	1.18			✓				✓				Growing regenerative market; integrates well with a polyculture system.
Sacha inchi	*Plukenetia volubilis*	Humid tropics					✓				✓	✓		
Sago Palm	*Metroxylon sagu*	humid tropics					✓							Harvested for starch. Grows in wet areas/ riversides- processed into the original tapioca balls- famous in Phatthalung
Santol, Sentul, Cotton Fruit	*Sandoricum koetjape*	humid tropical regions			✓		✓					✓	✓	fruit can be eaten raw or cooked; popular ingredient in many regional cuisines
Selasian Wood, Saffrol Laurel	*Cinnamomum parthenoxylon*	Tropics					✓			✓				being harvested at a high rate to obtain safrole, a precursor to the pesticide synergist piperonyl butoxide, the flavorant and fragrance piperonal, and the psychoactive drug MDMA
Sentang	*Azadirachta excelsa*				✓		✓			✓		✓		widely used as a raw material to produce veneer, particleboard, pulp and paper, furniture
Snake Fruit, Salak	*Salacca zalacca*	Tropics		✓			✓					✓	✓	Sweet-sour, astringent tasting fruit. Popular to-go snack in much of Southeast Asia
Star apple	*Chrysophyllum cainito*	Tropics					✓				✓	✓	✓	The fruits are used as a fresh dessert fruit; it is sweet and often served chilled. Infusions of the leaves have been used against diabetes and articular rheumatism. The fruit has antioxidant properties
Stink Bean, Bitter Bean	*Parkia speciosa*	Tropics					✓					✓	✓	popular as culinary ingredient in South and Southeast Asia
Sugar Palm	*Arenga pinnata*	Tropics				✓	✓	✓				✓	✓	Sap collected for sugar; also starch, fibers, leaves for basketry

Thailand/Southeast Asia

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Sweet orange	*Citrus x sinensis*	Subtropics to tropics	13.65				✓			✓		✓		
Sweet potato	*Ipomoea batatas*	Temperate to tropical	12				✓			✓		✓	✓	
Tamarind	*Tamarindus indica*	Subtropics to tropics			✓	✓	✓		medicine, oil	✓		✓		The fruit is edible but sour; used as a component of savory dishes, as a pickling agent, in chutneys and curries
Teak	*Tectona grandis*	Tropics			✓					✓		✓		
Turmeric	*Curcuma longa*	Temperate to tropical					✓	✓		✓		✓	✓	
Vanilla	*Vanilla genus*	Humid tropics	0.07				✓			✓		✓		
Vegetable Fern	*Diplazium esculentum*	Tropics		✓			✓		medicine			✓	✓	Edible fern. The young fronds are stir-fried and used in salads
Wild taro	*Colocasia esculenta*	Temperate to tropical	6.91	✓			✓		medicinal			✓	✓	Poisonous until cooked
Yam	*Dioscorea spp.*	Temperate to tropical	8.65				✓					✓	✓	

Sub-Saharan Africa

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Afezu	*Panicum turgidum*	Arid/Semi-Arid Tropics		✓			✓					✓	✓	Historic wild staple, wound dressing
African Breadnut	*Treculia africana*	Humid Tropics		✓			✓				✓	✓	✓	"[m]ay well be world's most productive source of edible protein" (Toensmeier)
African Locust Bean	*Parkia biglobosa*	Semi-Arid Tropics		✓	✓	✓	✓				✓	✓	✓	Ripens during dry season when there is little else to eat
African Oil Bean	*Pentaclethra macrophylla*	Humid Tropics		✓	✓		✓	✓	✓		✓	✓	✓	Flour alternative, good wood, oil, salt source, low-shading tree valued on farms
African Oil Palm	*Elaeis guineensis*	Humid Tropics	15-38 (fruit) 5-8.7 (oil)	✓		✓	✓			✓		✓	✓	Fruits, oil, kernels; "a great example of how even an extraodrinary plant can be terribly misused" (Toensmeier)
African Rice	*Oryza glaberrima*	Semi-Arid Tropics		✓			✓				✓	✓	✓	3,000 years of domestication, rarely sold within region
African Rosewood	*Guibourtia demeusei*	Humid Tropics		✓	✓						✓	✓		High quality wood, source of Congo copal (varnish/ lacquer ingredient)
African Walnut	*Coula edulis*	Humid Tropics		✓	✓		✓				✓	✓	✓	Valued nut, high quality wood
African Whitewood, Arere	*Triplochiton scleroxylon*	Humid Tropics		✓	✓		✓				✓	✓	✓	Edible leaves, medicinal, often grown as shade tree among cacao, lower quality, but useful wood
African Yam Bean	*Sphenostylis stenocarpa*	Semi-Arid Tropics		✓			✓				✓	✓	✓	Edible leaves, seeds, seedpods, tubers (high in protein)
Aizen, Hansa	*Boscia senegalensis*	Arid Tropics		✓			✓	✓	✓		✓	✓	✓	Valued food, sweetener, coffee alternative, medicinal, some woodwork, shelterbelt, "famine food"
Allanbackia species; Nsangomo	*Allanblackia sp.*	Humid Tropics		✓			✓		✓		✓	✓	✓	Edible oil (export potential), medicinal, "famine food"
Amaranth	*Amaranth sp.*	Tropics / Temperate					✓				✓	✓	✓	Native variety exists but unclear food potential
Bambara Bean	*Vigna subterranea*	Semi-Arid Tropics	0.59	✓			✓				✓	✓	✓	Cultivation particularly linked with women, 3rd most important leguminous crop
Banana, Plantain	*Musa spp.*	Humid Tropics	16.65				✓		✓		✓	✓	✓	Given lack of genetic diversity in commercial strands, non-Cavendish varieties are preferred, medicinal (roots)
Baobab	*Adansonia digitata*	Semi-Arid Tropics		✓		✓	✓	✓	✓		✓	✓		Large range of food applications, medicinal
Bitter Kola	*Garcinia kola*	Humid Tropics		✓	✓		✓		✓	✓		✓	✓	Medicinal, edible fruit and seeds, chewsticks, often used as shade tree among cacao
Cacao	*Theobroma cacao*	Humid Tropics	0.46			✓	✓	✓	✓	✓		✓	✓	Medicinal
Cashew	*Anacardium occidentale*	Semi-Arid Tropics					✓			✓		✓	✓	
Cassava	*Manihot esculenta*	Semi-Arid Tropics	10.62				✓		✓	✓		✓	✓	Medicinal, mulch repels root knot nematodes, adhesive
Celosia	*Celosia argentea cristata*	Semi-Arid Tropics		✓			✓		✓		✓	✓	✓	Medicinal, valued food, used as biological control of parasitic Striga plant

Sub-Saharan Africa

NAME		SUITABILITY	YIELDS	INDIGENOUS?	PRODUCT TYPE					MARKETS				NOTES
ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Chocolate Berries	*Vitex payos*	Semi-Arid Tropics		✓	✓		✓		✓		✓	✓	✓	Medicinal, some woodwork, popular as mulch (leaves) - fruit flavor is characterized as challenging for Westerners
Country Onion	*Afrostyrax lepidophyllus*	Humid Tropics		✓			✓				✓	✓	✓	Red listed (VU), used as spice
Cowpea, Black-Eyde Pea	*Vigna unguiculata*	Semi-Arid Tropics	0.6	✓			✓		✓	✓		✓	✓	"exceptionally rich in useful genetic diversity. It produces several different tasty foods. The plant is deep rooted, vigorous in growth, and reliable in production." (Lost Crops II)
Custard Apple, African	*Annona senegalensis*	Semi-Arid Tropics		✓	✓	✓	✓		✓		✓	✓	✓	Valued fruit, medicinal, some woodwork
Dika Nut	*Irvingia gabonensis*	Humid Tropics		✓	✓		✓	✓	✓		✓	✓	✓	Highly valued nut, medicinal, oils, wax, soap, "Gabon Chocolate"
Djansang, African Oil-Nut Tree	*Ricinodendron heudelotii*	Humid Tropics		✓			✓				✓	✓	✓	Balsawood alternative, multiple medicinal and crafts uses, "famine food"
Drinn	*Aristida pungens*	Arid to Semi Arid		✓			✓					✓	✓	Historically central grain, extremely drought tolerant
Ebony (Diospyros species)	*Diospyros spp.*	Tropics			✓		✓			✓		✓	✓	High value wood, medicinal, some spp. have valued fruit
Egusi	*Citrullus colocynthis*	Arid Tropics		✓			✓		✓		✓	✓	✓	Oils, medicinal
Egyptian Balsam	*Balanites aegyptiaca*	Arid Tropics		✓			✓	✓	✓		✓	✓	✓	Medicinal, oil, good fuel source
Emmer	*Triticum turgidum*	Arid to Semi Arid				✓	✓			✓		✓	✓	5,000 years of cultivation in Horn of Africa, central culturally
Enset, Ethiopian Banana	*Ensete ventricosum*	Semi-Arid Tropics		✓		✓	✓				✓	✓	✓	Flour alternative, strong fibers
Eru, African Jointfir	*Gnetum africanum*	Humid Tropics		✓		✓	✓		✓		✓	✓	✓	Popular vegetable, medicinal, strong fibers
Faux Muscadier	*Monodora myristica*	Humid Tropics		✓	✓		✓		✓		✓	✓	✓	Nutmeg alternative, medicinal, oil
Finger Millet	*Eleusine coracana*	Semi-Arid Tropics	0.97	✓			✓		✓		✓	✓	✓	Important staple, but often undervalued as "food for poor"
Fonio	*Digitaria exilis, Digitaria iburua*	Semi-Arid Tropics	0.7438	✓			✓				✓	✓	✓	Possibly oldest cultivated grain in West Africa
Gingerbread Plums	*Parinari and kindred genera*	Semi-Arid Tropics		✓	✓		✓	✓	✓		✓	✓	✓	Durable wood, medicinal, good fruits, oils
Gum Arabic	*Acacia senegal / Senegalia senegal*	Arid, Semi Arid Tropics		✓			✓	✓	✓			✓	✓	Valuable fuel in coppice cultivation, valued gum
Gumvines	*Landolphia spp. / Saba spp.*	Semi-Arid Tropics		✓			✓		✓		✓	✓	✓	Edible fruit pulp, medicinal, good latex producer
Horned Melon	*Curcumis metuliferus*	Tropics		✓			✓		✓		✓	✓	✓	Medicinal (vermifuge)
Icacina	*Icacina spp.*	Tropics		✓			✓		✓				✓	Medicinal, sources refer to this as "famine crop"

Sub-Saharan Africa

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ENGLISH NAME	SCIENTIFIC NAME	CLIMATE	TONS/HA	YES/NO	TIMBER	FIBER	FOOD	COSMETIC	OTHER	EXPORT	EMERGING	LOCAL	SUBSIS-TENCE	
Jujube	*Ziziphus mauritiana*	Semi-Arid Tropics		✓			✓		✓	✓		✓	✓	Valued fruit (fresh and dried), high vitamin C
Kei Apple	*Dovyalis caffra*	Sub-Tropics		✓			✓		✓		✓	✓	✓	Often used as living fences
Lablab Bean	*Lablab purpureus*	Tropics		✓			✓		✓		✓	✓	✓	Medicinal properties, strong traditional food in Kenya
Mahogany	*Swietenia macrophylla*	Semi-Arid to Humid Tropics			✓				✓	✓		✓		Superior quality wood, some medicinal uses
Mango	*Mangifera indica*	Humid Tropics	9.54				✓			✓		✓	✓	Medicinal, lighter construction
Mangosteen, African	*Garcinia livingstonei*	Semi-Arid Tropics	9.54	✓	✓		✓		✓		✓	✓	✓	Valued fruit, leaf and flower extracts antibacterial properties
Marama Bean	*Tylosema esculentum*	Arid Tropics		✓			✓				✓	✓	✓	Coffee substitute, cashew-like
Marula	*Sclerocarya birrea*	Arid Tropics		✓			✓	✓	✓		✓	✓	✓	Sweetener, vitamin C, medicinal
Medlars	*Vangueria species*	Semi-Arid Tropics		✓			✓		✓			✓	✓	Medicinal, some crafts
Monkey Oranges	*Strychnos species*	Semi-Arid Tropics		✓			✓				✓	✓	✓	Coffee substitute, medicinal, water filtration, tools material
Moringa	*Moringa oleifera*	Semi-Arid Tropics					✓	✓	✓	✓		✓	✓	Very rapid grower with large variety of uses
Moringa, African	*Moringa stenopetala*	Semi-Arid Tropics		✓			✓	✓	✓		✓	✓	✓	Very rapid grower with large variety of uses
Num-Num	*Carissa spp.*	Semi-Arid Tropics		✓			✓				✓	✓	✓	Edible fruit, living hedge
Potato, African	*Hypoxis hemerocallidea*	Semi-Arid Tropics		✓			✓		✓		✓	✓	✓	Mint family with root crop, medicinal
Peanut	*Arachis hypogaea*	Tropics, Sub-Tropics	1.65				✓	✓	✓	✓		✓	✓	
Pearl Millet	*Pennisetum Glaucum*	Semi-Arid Tropics					✓				✓	✓	✓	
Sabi Grass	*Urochloa mosambicensis*	Semi-Arid Tropics		✓			✓				✓	✓	✓	Edible seed, very effective in establishing groundcover
Safou, African Plum, Butterfruit (I)	*Dacryodes edulis*	Humid Tropics		✓	✓	✓	✓	✓	✓		✓	✓	✓	Medicinal, soil fertility indicator
Shea Butter Tree	*Vitellaria paradoxa*	Semi-arid Tropics	1.77	✓	✓		✓	✓	✓		✓	✓	✓	The "butter" of West Africa, central cultural crop
Sorghum	*Sorghum bicolor*	Semi-arid Tropics	1.5	✓		✓	✓	✓	✓	✓		✓	✓	Brewing, weaving, fuel, roofing, adhesive, tanning, dye
Star Apple	*Chrysophyllum albidum*	Humid Tropics		✓	✓				✓		✓	✓	✓	Timber, medicinal use, some latex extraction
Sugarplums	*Uapaca spp.*	Humid Tropics		✓			✓				✓	✓	✓	"One of the most popular wild fruits"
Sweet Detar	*Detarium senegalense*	Semi-arid Tropics		✓	✓		✓		✓		✓	✓	✓	Prominent medicinal plant, high value timber

Sub-Saharan Africa

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Sweet Potato	*Ipomoaea batatas*	Humid Tropics	12				✓					✓	✓	
Tamarind	*Tamarindus indica*	Semi-arid Tropics		✓	✓		✓		✓		✓	✓	✓	Central culturally, mixed with sorghum and millets, storable pulp
Teff	*Eragrostis tef*	Semi-Arid Tropics		✓			✓			✓	✓	✓	✓	Staple annual, already some export
Tree Grapes	*Lannea spp.*	Semi-Arid Tropics		✓		✓	✓		✓		✓	✓	✓	Highly valued fruit, highly valued bee nectar source, fiber for cordage
Veg Tallow Tree	*Allanblackia parviflora*	Humid Tropics	2.47	✓	✓		✓	✓	✓	✓	✓	✓	✓	Industry interested in fatty acid from nuts, oils for cosmetics, twigs as candlesticks, chew-sticks, decent timber that is termite repelling
Yam	*Dioscorea spp.*	Humid Tropics	8.65	✓			✓		✓		✓	✓		Leaves used as tea
Yeheb	*Cordeauxia edulis*	Arid Tropics		✓			✓		✓		✓		✓	Contains cordeauxiaquinone (brilliant red dye), valued nut, pastoral plant
Yohimbe	*Pausinystalia yohimbe*	Humid Tropics		✓					✓		✓	✓		Highly valued medicinal plant and stimulant