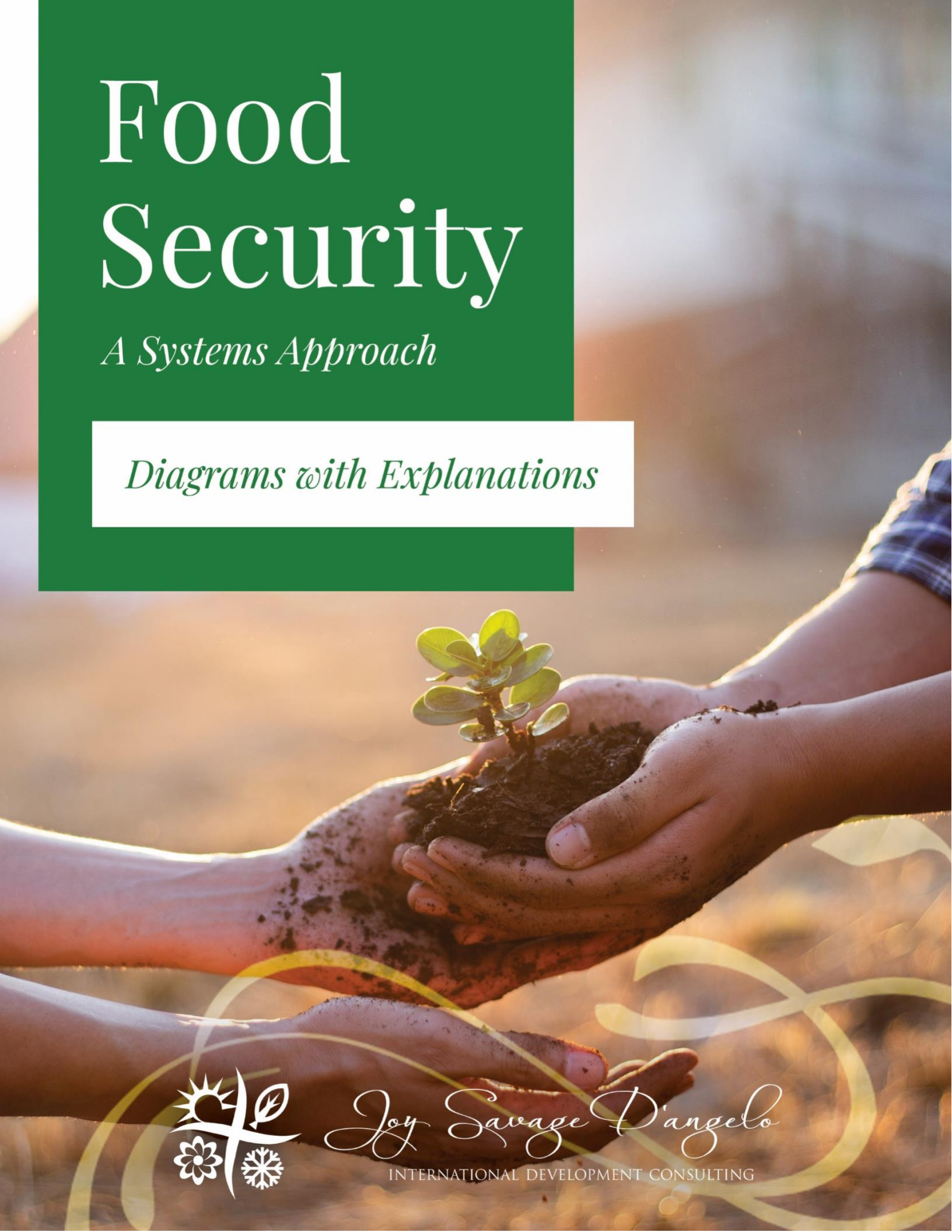
Food Security

A Systems Approach

Diagrams with Explanations



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Introduction

Dear Reader,

I wrote this with you in mind. Maybe you're an agricultural minister or practitioner, someone responsible for your nation's food security policy or a dreamer who wants to see more food get to more people. You've got a background in one area, but may need a high-level systems view to make the connection on where the problem might be within the larger system. To help, I've diagrammed the whole food-security system in a way which gives a quick reference, quick overview of the different elements in the hope that it inspires you to see and to solve the issues most pressing to you. Have a look and see what you think. And if you need any help, let me know.

Best wishes,

Joy D'Angelo

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A Systems Approach

About the diagrams

This unique systems map was designed by reflecting upon the different challenges faced by the many actors at the micro, meso and macro levels, each with a different perspective and prerogative. Recognizing the need for context when analyzing the risk waterfall and ownership grid for a new solution, I wrote this for policy makers, business people and any other resilience advocate across the agrifood system to be useful regardless of national development stage. It is meant to diagram the system in order to illuminate the different pieces, their individual functions and relationships to each other. It can also help to identify a missing piece, or one in need of repair or just improvement for the better functioning of the whole system.

FAQs

In contrast to previous work, I have considered waste reduction to be an important by-product of an efficient system or a goal when fixing any one element in order to achieve food security, rather than an element in itself. I have also considered improving access as an over-arching goal for some, and not the focus for others (Ex: the goal may be improving production where supply lines are adequate). I have also not explicitly identified security issues (i.e. conflicts leading to the control or restriction of supply, certain areas or passageways, war or just bandits) choosing to focus on diagraming the system rather than threats, as these can vary immensely in type, definition and bearing on any particular situation. Political will is also a cross-cutting issue and will vary for each piece according to the times. The goal of these diagrams and explanations is to help inspire solutions by seeing all the pieces of a system in one place.

You will notice I have put a singular element at the core, which I have called “marketing, training, and regulating structures”. This also includes any mutually informing mechanism such as a farmer’s association or feedback mechanism.

Excellent examples of these are:

Wales: Farming Connect
https://businesswales.gov.wales/farmingconnect/

New Zealand: Dairy
https://www.dairynz.co.nz/

Beef, Lamb and everything else:
https://beeflambnz.com/

California: Community Alliance with Family Farmers (CAFF)
https://www.caff.org/

Kenya: Shamba Shape Up
https://www.voanews.com/africa/reality-tv-show-helps-farmers-improve-livelihoods

About the Author

Joy Savage D’Angelo is an international development researcher and consultant focusing on organizational resilience. She is also a certified project manager, permaculture designer and life coach. Drawing from her involvement in projects in over 20 different countries both in peacetime and in conflict, she is appreciated by leaders all over the globe for distilling complex concepts into bite-sized, actionable steps.

For more information or use enquiries:
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Cover Photo: Young seedlings are ready to grow in fertile soil, Agriculture gave the young men trees to prepare for planting and reduce global warming, Save world save life and Plant a tree concept © Puwasit Inyavileart / Adobe Stock

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Soil science peer review: Santosh S. Palmate, Phd

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Food Security

Systems Development Framework

Technical Explanations

Whole System Overview

Production and Water Systems

Everything from what the farmer has access to in terms of land, water, seed, tools and know-how, to storage, markets, and means of distribution plays a role (see production-focused diagram and explanations). In terms of security or stability of production, having access to quality seed, and insurance or financial alternatives (like diversification of income to keep the farm afloat during difficult times), are crucial.

Literally, underneath it all is the quality of soil. Poor soils can be rehabilitated with time and the right strategies. Healthy soils are actually more water-use efficient and require fewer inputs if the right system is put into place. They hold more nutrients and keep them available to the plant in times of drought, and do not easily wash away in floods.

Access to water is another key issue. Whether it is available on the surface, through wells, dew, qanats, rain use efficiency techniques, amount and timing are important. Sometimes obtaining the right-to-use can be an issue, depending on the location and national set-up or any disputes with neighbors. Right-to-capture or store may also be important elements to consider, as well as any materials and techniques required for doing so.

On-Farm Storage

Proper on-farm storage is key, both for any inputs needed and for the harvest until time for use, distribution, or transport to market. Proper on-farm storage adapted to the climate and its purpose helps reduce loss, increase profitability, and improve market opportunities.

Secure, Reliable, and Well-maintained Transport and Infrastructure

These systems are also important to ensure food security, not only by getting it to market but also by preventing unnecessary loss in transit. When roads are safe from bandits and in good repair, and when vehicles work or can be repaired quickly and at a reasonable price, food loss in transit will be minimized.

Also, where cold chain storage and logistics are important, transport and infrastructure being in good repair and of the right type for the climate concerned is vital. This involves accurate planning, logistics, health and safety policies and trained personnel for proper maintenance, as well as the right provenance of contracts, both for building and maintaining the system.

The cost and financing of such a system may be prohibitive; or it could present a good challenge for the local economy to step up to the plate - provided investment financing is available - and build something locally that works and is more adept for the long term. Taking up this challenge however may involve local, regional or national governments, or even international trade agreements, in addition to solid private companies, depending on any existing set-up. It may also provide an opportunity to lay a foundation for a transport network authority or planning committee. A community-based survey may also be helpful to making sure new roads are built in and through the right places.

Market Availability and Profitability

Access to profitable markets is key to the long-term sustainability for the business plan of any farm, be it a one-family, mainly for sustenance endeavor, or a large-scale operation meant for export or national distribution. A market needs to exist that is accessible to both the farmer and the purchaser: it's pointless to grow bamboo, for example, where there is no access to a market for it, or when it causes financial loss getting it there.

The product must be affordable to the end consumer despite any middlemen, storage or processing required, while remaining interesting and profitable enough for the farmer to grow.

Value Addition Processing and Packing

This is simply a part of making the farm product accessible, usable, or desirable to the consumer or middleman. This may be cleaning, prepping into something else, or putting in a format to be consumed.

Health and Safety

Health and safety issues are particularly important for the export and sale of farm products. Here *Health and Safety* refers not only to the human labor concerns and interactions with the products or machines, but more specifically to any effort made to preserve the integrity of the farm product throughout its journey to the end consumer and until consumption or disposal.

Some countries may have different standards for importing a farm product than the country where it was produced, and adjustments may need to be made for that customer. Otherwise, where the sale is local, national and regional considerations should be taken into account.

Consumption practices, business ideas, and any national plans may drive what it is necessary both on farm and further along the chain for packing, storing, transit, and sale. Restaurants and consumers may have different consumption patterns and therefore different health and safety requirements, as may foreign export markets compared to home-based ones.

Import and Export Agreements

Alternative arrangements may be necessary for stabilizing supply throughout the year, for creating economic opportunities or for cultivating trade relationships. Many details need to be taken into consideration, such as: health and safety requirements of the end market; any processing or value additions to make the products more useful and increase the number and size of economic opportunities at home; and the legal considerations in any of the countries concerned.

Intermediary Storage

Anywhere the products are stored, between the farm and the end market is intermediary storage. Such storage depends on how far the products must travel or how many distributors' hands they must pass through before reaching the end consumer and until consumption. In effect, the market itself is a place of intermediary storage as well, not just a warehouse or truck the products might pass through beforehand.

Attention must be paid throughout this chain to health and safety concerns, regulations and any tracking and tracing required for sale in the domestic market or for export.

Storage and Consumption

This refers to whether a consumer has access to a refrigerator or means of disposing of non-biological waste, any means of cooking, storing or preparing the product and its most desirable format and frequency. For example, whether or not the consumer has electricity or a refrigerator will make a difference in the types, variety, timing and format required. Sometimes, how a farm product is packed can significantly extend its shelf life and therefore contribute to security by decreasing unnecessary loss.

Nutrition

Nutrition can vary according to lifestyle, life stage, gender, climate and the availability of complimentary products. Generalizations can be identified: for example, a general lack of iron or meat or other key nutrients, integrated into a public health plan can complement any food security plan or economic efforts related in the trade, import or export of farm products.

Awareness and Capacity Building

This refers to all the marketing, training and regulating structures that hold the system together. This is what is used to communicate with farmers, consumers and anyone involved in the sale or distribution of farm products.

This may be a government channel, private effort or combination of both. For example, often times farmers associations fill this role on the ground even if there is an agricultural minister or other trade and consumption division of government. The former may communicate new rules, form opposition to new laws and disseminate helpful information and training on useful topics, such as pest management and farm business management. The latter however, may be the one aware of or responsible for making sure that economic and public safety concerns are met throughout the process.

For further examination of any of these dimensions and how they may be improved, feel free to contact me.

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Distribution Systems Development for Agricultural Products

Distribution Focus

On-farm Storage and Preparation

Having proper on-farm storage adapted to climate and purpose helps reduce loss, increases profitability, and improves market opportunities. Some pre-packing or processing may be required to make it ready for sale.

Transport and Logistics

This is everything required to get farm products to market. It may involve an entire ecosystem of coordination between farmer and market and everyone in between or it can happen quite informally.

Processing and Packing

This stage is what makes the farm product sellable, even when processing and packaging are minimal.

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The product must be affordable to the end consumer despite any middlemen, storage or processing required, while remaining interesting and profitable enough for the farmer to grow.

Import/Export Agreements and Planning

Import and export agreements may be key to stabilizing supply throughout the year, for creating economic opportunities or for cultivating trade relationships. Many details should be taken into consideration, such as health and safety requirements of the end market, any processing or value addition to make the products more useful and to increase the number and size of economic opportunities at home, and any legal considerations in any of the countries concerned.

Repair and Maintenance of Vehicles and Infrastructure

Secure, reliable, and well-maintained transport and infrastructure systems are also important to ensuring food security, not only by getting it to market but also by preventing unnecessary loss in transit. When roads are safe from bandits and in good repair, and when vehicles work or can be repaired quickly and at a reasonable price, food loss in transit can be minimized. Also, where cold chain storage and logistics are important, their being in good repair and of the right type for the climate concerned can be crucial.

This involves accurate planning, logistics, health and safety policies and trained personnel for proper maintenance, and the right provenance of contracts both for building and maintaining the system. Cost and/or financing can be prohibitive; or it could present a

good challenge for the local economy - provided investment financing is available - to build something local that works just as well and is more adept for the long term. This may involve local, regional, or national governments, depending on any existing set-up. Or, this may provide an opportunity to lay a foundation for a transport network authority or planning committee. A community-based organization may also be helpful in making sure new roads are built in and through the right places.

Internet and data connectivity can not only improve harvests through precision agriculture, but can improve market efficiency by helping get the right products to the right consumers at the right time. This would also help reduce loss in the system and increase profitability for the farmer and anyone in between.

Where electricity is prevalent and reliable enough, things like cold storage, washing and packing for export can be made easier or simply possible on a larger scale.

If you need help identifying where a problem may be or what to develop first, feel free to contact me.

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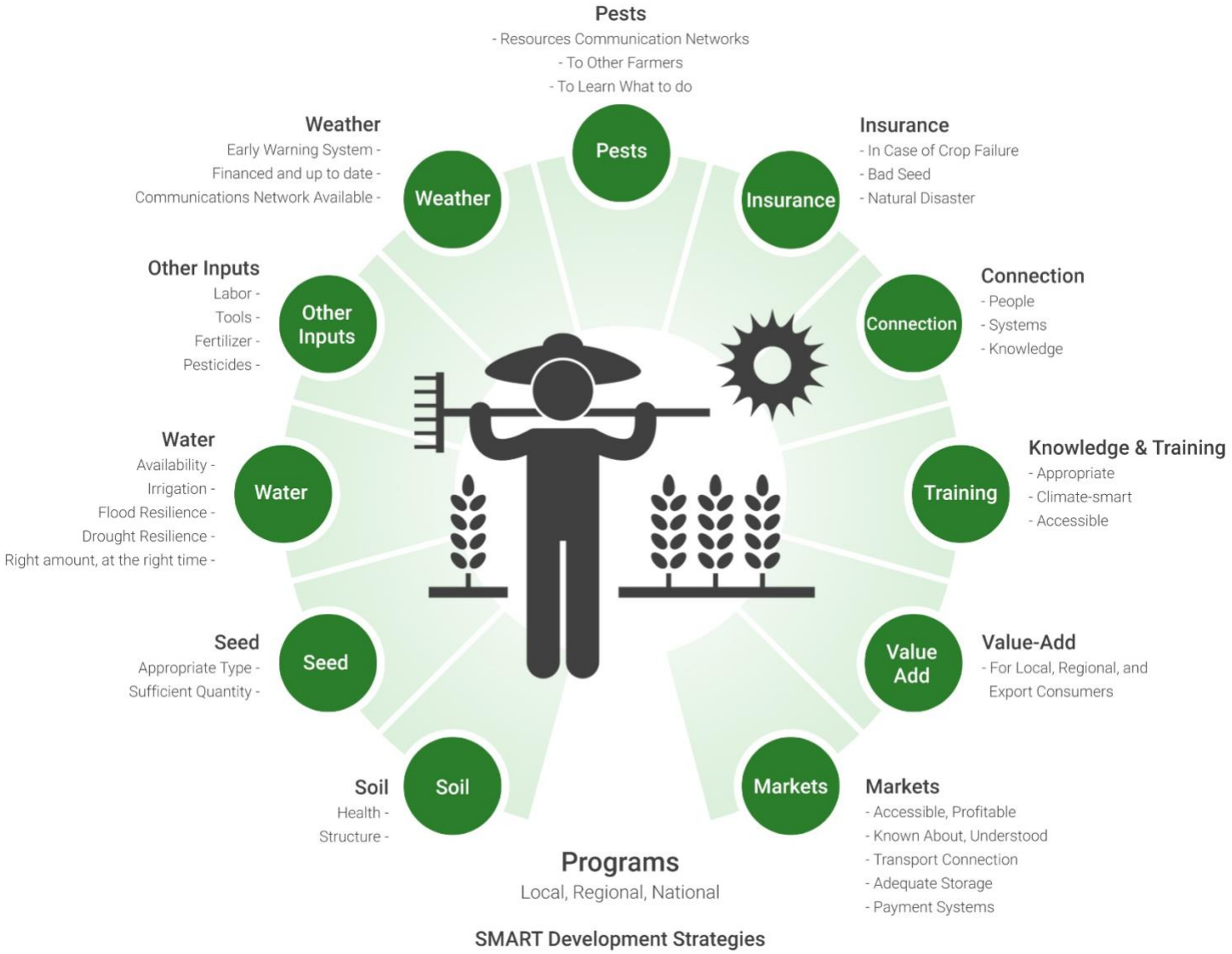
Agricultural Production Systems



Production Focus

Soil

Having healthy, well-structured soil can make all the difference. Literally, underneath it all is the quality of soil. Poor soils can be rehabilitated with time and the right strategies. Healthy soils are actually more water-use efficient and require fewer inputs if the right system is put into place. They hold more nutrients and keep them available to the plant in times of drought, and do not easily wash away in floods.

Seed

Access to the appropriate type of seed in sufficient quantity and at the right time is also important.

Water

Access to water is another key issue. Whether it is available on the surface, through wells, dew, qanats, rain use efficiently techniques, amount and timing are important. Sometimes obtaining the right-to-use can be an issue, depending on the location and national set-up or any disputes with neighbors. Right-to-capture or store may also be important elements to consider, as well as any materials and techniques required for doing so.

Other Inputs

Having the right labor, adequate tools, and any fertilizer or pesticides which may be appropriate.

Weather

Access to weather forecasts can improve the timing of planting, irrigation, and harvesting. Early warning systems can help mitigate damage, however, these must be financed and kept up to date. A dependable, appropriate communications network is necessary for this to occur.

Pests

Knowledge and training can be vital for mitigating pests and disease. Access to resources, other farmers and or a central database or a sort of command center on how to treat, prevent and repel a particular pest can be essential to avoiding wider crop failure and consequently, lack of local food supply. This requires good communication networks and access to relevant data.

Insurance

This added security can be important to help the farmer stay in business by mitigating the risks of crop failure, bad seed, inclement weather or natural disaster. This can happen naturally through farm business strategies like diversification, savings, supply and strategic crop planting, or through an outside entity like a firm, provided it meets the farmer's needs at an appropriate pricing structure and timing of payments.

Connection

Connection to other people, systems and knowledge is crucial to the farmer's mental health, ability to produce something for profit, and to reduce loss from pests, disease epidemics.

Knowledge and Training

Access to up-to-date knowledge on pests and disease, best farming practices and regulations can help better value foods get to market in better quantities. This often requires a system or platform for connecting people and sharing knowledge. Preserving and disseminating local knowledge however can be just as crucial to making resilient, climate-smart decisions.

Value-add

Value addition in processing and packing are simply a part of making the farm product accessible, usable or desirable to the consumer or middleman. This may be cleaning, prepping into something else or putting in a format to be consumed. Requirements may vary, even at farm-level for local, regional or export consumers.

Markets

Market availability and profitability are key to the long-term sustainability for the business plan of any farm, be it a one-family mainly for sustenance endeavor, or a large-scale operation meant for export or national distribution. A market needs to exist and be accessible to both the farmer and the purchaser for what is produced. It's pointless to grow bamboo for example, where there is no access to a market for it, or when it causes financial loss getting it there.

The product must be affordable to the end consumer despite any middlemen, storage or processing required, while remaining interesting and profitable enough for the farmer to grow.

Both parties must also be aware that a market exists and understand how it works. For example, if the marketplace is online, farmers may need training on how to sell there or get their products to the end consumer, and both parties will need the confidence that the exchange of money and items can and will take place as agreed.

Where the exchange occurs in a physical place, safety and adequate transport links must be assured to get both products and consumers to the market. Proper, adequate intermediary and temporary storage of goods are also a requirement. Payment systems must be usable for both parties. Digital infrastructure and training may be required to bring producers, middlemen or marketplaces in line with consumer demands and preferences.

Programs

Whether governmental, operated through the private-sector or a public-private partnership, having an idea of where you want to go in terms of strategy, and at what level to implement a program will help get you on track to building a food security system for your people.

If you need help doing this, let me know. Your strategy will need to be appropriate and take into account where you are currently, what your resources and strengths are and what next steps are reasonable to achieve.

Soil Focus

Improved Soil Ecology

Good structure provides pores for more microbiota to reside, nest and multiply. When further improved by organic carbon, even more positive bacteria, fungi, and nutrients are available in the topsoil. These elements also reduce erosion from wind and flooding, as well as reduce the need for chemicals.

Reduced Chemical Load

By keeping a wider variety of naturally occurring nutrients in proximity to plant roots (rhizosphere) through the availability of diverse organic matter (SOC) fostered by good structure, fewer industrial inputs are needed.

More Economical

By keeping a wider variety of naturally occurring nutrients and retained water in proximity to plant roots (rhizosphere) through organic matter (SOC) and proper structure, fewer manufactured and possibly imported inputs are needed and less water is required, thus reducing costs and boosting productivity.

Improved Resilience to Temperature and Climate Variation

The increase of pores in the topsoil via good structure, particularly when created by organic carbon create places for water droplets to form, accumulate and stay for longer periods of time. This availability of water helps the plant to cope with sudden fluctuations of temperature and dryness, while maintaining its ability to absorb a sudden onset of rain. Like a sponge, soil needs a minimum of moisture already in the membrane in order to absorb and to retain more water.

Wind Erosion

Well-structured soils usually have vegetation cover nearly year-round, which makes them naturally heavier, better anchored and less exposed to the wind. During rehabilitation and between crops where there is little to no cover for a period, healthy, well-structured soils are still heavier and better held together through the soil food web, thereby reducing the number of loose particles vulnerable to being swept away by the wind.

Better Soil Moisture Retention

The increase of pores in the topsoil via good structure, particularly when created by organic carbon create places for water droplets to form, accumulate and stay for longer periods of time. (This is referred to as capillary water or field capacity)

Better Drought Resilience

Improving Soil Organic Carbon (SOC) in topsoil keeps water and nutrients available to plants for longer. [i]

Better Flood Resilience

Soil structure breaks up the soil and fosters pores to receive rain and irrigation water, rather than just letting it run off the top like in soil crusting, compacted soils, and sandy soils, all of which quickly turn into a clay-like, virtually impervious texture with heavy rain, which in turns gives way to more flooding. On degraded soils in hilly regions, poor structure could mean the catena (upper layer of soil along a hilltop) would be more likely to slide in heavy rain.

Better Fire Resilience

Good soil structure helps keep moisture and nutrients available in the rhizosphere for any surviving plants. It may even help some species survive the fire itself, by giving it what it needs to survive the fumes, ash, and sudden dryness (also called water stress) associated with nearby fire.[ii]

Improved Water Quality

By slowing the flow of water through pores and organic matter, thereby increasing the time it takes for water to filter back into the groundwater sources, better water quality can be achieved. These same facts reduce the amount of topsoil runoff into surface water sources, too.

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[i] Izumi, T., Wagai, R. 2019. Leveraging drought risk reduction for sustainable food, soil and climate via soil organic carbon sequestration. Sci Rep 9, 19744 https://doi.org/10.1038/s41598-019-55835-y

[ii] Knox KJE, Clark P J. 2005. Nutrient availability induces contrasting allocation and starch formation in resprouting and obligate seeding shrubs. Functional Ecology 19, 690–698

[iii] D'Angelo, J. et al 2023. Mitigating risks of hybrid rice use in terrace agriculture. Geography and Sustainability, 4 (1), p. 1-5. https://doi.org/10.1016/j.geosus.2022.11.002

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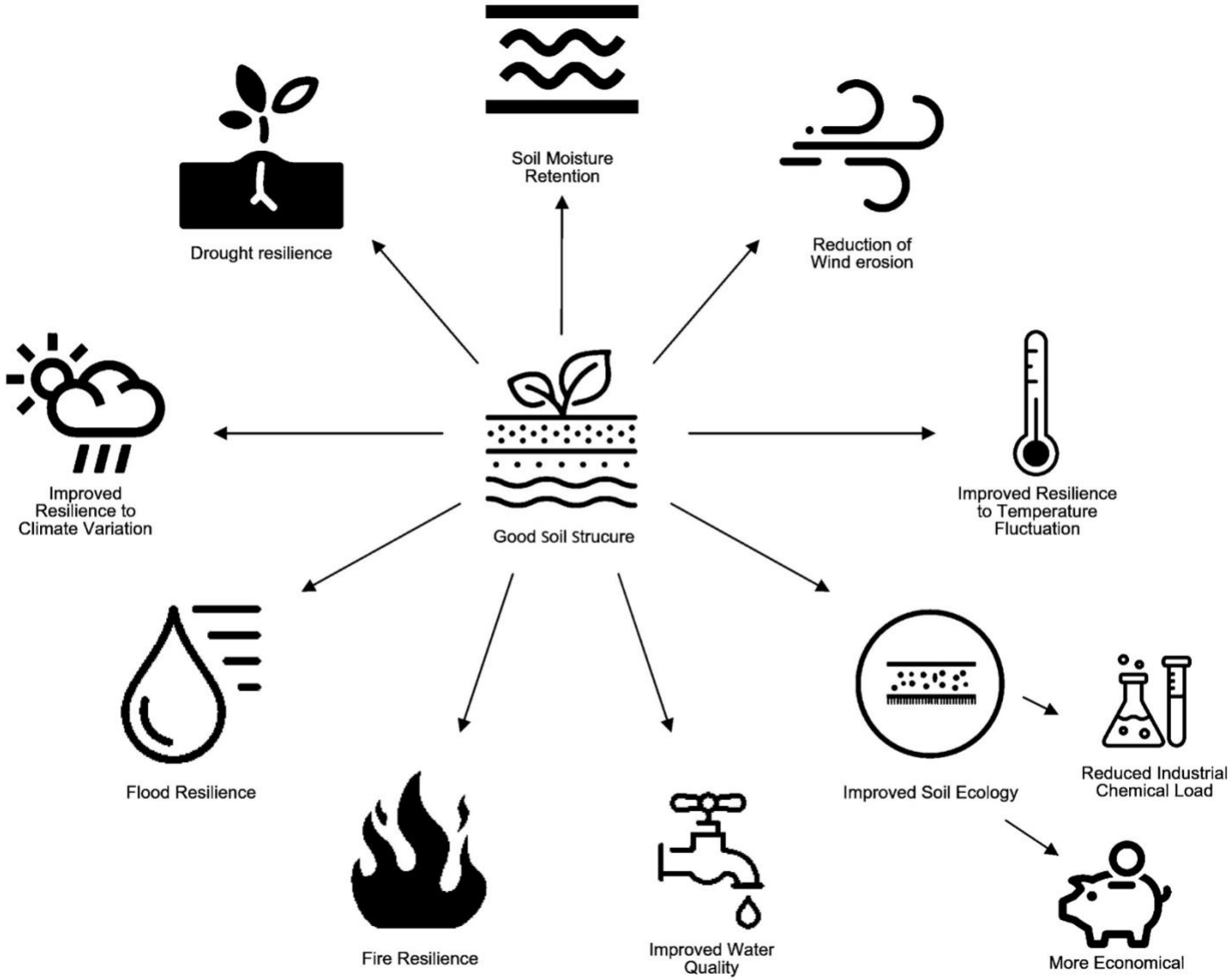
Soil Structure :

A Key to Resilience



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Why Soil Structure is Key to Resilience

Benefits Explained

Improved soil ecology

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Better soil moisture retention

The increase of pores in the topsoil via good structure, particularly when created by organic carbon create places for water droplets to form, accumulate and stay for longer periods of time. (Capiliary water, field capacity)

More economical

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Better flood resilience

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Reduced chemical load

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Improved water quality

By slowing the flow of water through pores and organic matter, thereby increasing the time it takes for water to filter back into the groundwater sources, better water quality can be achieved. These same facts reduce the amount of topsoil runoff into surface water sources, too.

Resilience Systems

Resilient in this case meaning: “the ability to keep going in spite of…”

For food security, a key element is soil health, which was discussed in the previous section. At the production level, having insurance or a financial alternative can help ensure supply. At a national level, having alternate suppliers or agreements with other regions or nations to fill the gaps helps ensure continuity of supply, as can planning for disasters and famine. Finally, having resilient transport and communications infrastructure in place helps mitigate any interruptions due to disaster or damage from conflict.

Here we look at systemic elements to ensure minimal disruptions to productivity and accessibility.

Planning for and maintaining well-managed storage and distribution centers can also help ease times of famine or disaster.

Soil Health

A number of strategies including crop rotation, cover cropping where possible, and fire and windbreaks help contribute to creating and maintaining good structure described above. Intercropping may also be useful for biodiversity needed to reduce the chemical load, and on slope and terrace agriculture to mitigate the risks of landslides, all contributing to resilient soil structure. [iii]

Having Alternatives

In terms of security or stability of production at the farm level, having access to quality seed and insurance or other financial alternatives to diversify income can be critical to keeping the farm afloat during difficult times.

At the national level, having alternate import/export arrangements with other nations or regions in place to even out the supply throughout the year can help build long term. Where disaster vulnerabilities are known, planning and prevention measures can help mitigate or reduce food security risks due to disaster.

Resilient Transport and Communications Infrastructure

Finally, having resilient transport and communications infrastructure in place helps mitigate any interruptions due to disaster or conflict

Key Elements of Systemic Resilience

As defined as: "The ability to keep going in spite of..."

Disaster risk reduction (DRR), productivity and accessibility over the long term all require:

- **Soil health**
- **Insurance or financial alternatives at the right time**
- **Transport and Communication infrastructure**
- **Agreements or provisions for alternate scenarios**