Postharvest Assessment Methodology

Conceptual framework for a methodology to assess food systems and value chains in the postharvest handling of perishables as a basis for effective interventions

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Institute: Wageningen Food & Biobased Research

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Abbreviations and Acronyms

B2B	Business-to-business
BP	Business plan
DESTEP	Demographic, Economic, Social, Technological, Ecological, Political
ECOWAS	Economic Community of West African States
FLID	Farmer-led Irrigation Development
FOREX	Foreign exchange (Foreign currency)
FS	Food System
F&V	Fruit and Vegetables
GHG	Greenhouse Gasses
IBRD	International Bank for Reconstruction and Development
KFFs	Key Failure Factors
KSFs	Key Success Factors
LMIC	Low and Middle-Income Countries
MoA	Ministry of Agriculture
MRLs	Maximum Residue Levels (of chemical crop protection)
MSME	Micro, Small, Medium sized Enterprises
N-P-K	Nitrogen - Phosphorus – Potassium (fertilizer)
PH	Postharvest
RH	Relative Humidity (of the air)
SDGs	Sustainable Development Goals
SEIA	Social and Environmental Impact Assessment
SOPs	Standard Operating Procedures
SME	Small, Medium sized Enterprises
SWOT	Strengths, Weaknesses, Opportunities, Threats
ToR	Terms of Reference
UN	United Nations
UPOV	The International Union for the Protection of New Varieties of Plants
VC	Value Chain
WB	World bank
WSM	Wholesale market

Executive summary

Background

Large amounts of money are invested in interventions in Low- and Middle-Income Countries (LMICs) aimed at improving food systems to meet current and future challenges related to population growth, climate and food security, amongst many other fields of focus.

Postharvest (PH) handling has a major impact on food quality and loss reduction. Food loss percentages of many crops in African and Asian LMICs range from 15 to 30% and even higher for mango, yam and cassava; reduction of these losses can greatly contribute to improving food availability, affordability and more stable prices, efficient resource use and stable income for producers and value chain actors.

However, in many cases, the success of these interventions is limited or at least sub-optimal. The reason for this is that food systems are diverse and consist of many different aspects, stakeholders and interests, often with complex interdependencies. Overlooking one aspect may have a huge impact on the implementation of an intervention. On the country level, cooling is often seen as the primary solution for addressing postharvest losses and quality issues. In a report on energy efficient cold storage for agriculture in Rwanda (Oostewechel et al. 2021), Wageningen Food & Biobased Research (WFBR) stated that just assuming that this is the case in all circumstances often leads to investments in projects that are inefficient or result in 'White Elephants' (expensive building projects that fail to deliver on its function or becomes very costly to maintain). Often high-quality cooling facilities were not used after project-end because of being built in the wrong location, having a too high cost-price with a product/market combination that did not justify investment, insufficient starting quality of the produce to be cooled, a lack of equipment maintenance or being unable to keep the cold chain closed.

Aim: improving efficiency and success rates of PH interventions

In order to increase the success rate of interventions in the postharvest handling of perishable crops and the impact per dollar spent, a thorough assessment is vital for a better understanding of all factors making up the enabling environment. The same is true of assessing risks and mitigating the possible negative side-effects of interventions. This kind of methodology has not been developed before, yet it could significantly contribute to improving the efficiency and success rates of interventions in LMICs worldwide.

This paper describes the proposed set up and content of this new methodology to establish a stepping-stone toward a comprehensive postharvest assessment methodology.

Conceptual framework and scope

One major principle included in the assessment should be that, for any intervention, the level of technology should match the level of market sophistication (Verschoor et al. 2020). Another consideration is that, for any intervention, the financial benefits for value chain decision makers or investors must be greater than the costs. If not, activities will simply stop after an intervention or the end of a project. Goals at the food system level must therefore be aligned with the interests at the value chain level. For the fruit and vegetable sectors, the requirement for a cold chain per crop/market combination also needs to be considered. In some cases, part of the chain could operate without cooling services, a concept known as ambient chains. This requires customisation, which greatly influences investment and operational costs, type and location of technology implemented, as well as energy consumption.

The methodology is designed in such a way that it can be used for different sectors, covering a wide range of perishable products, including milk, root crops, grains and pulses, fruit and vegetables. It also covers the full postharvest chain, including transportation, storage and processing. It must also be suitable to assess: (i) existing investment plans in postharvest interventions in specific sectors, and (ii) the situation in a country or region with the aim of producing a document that provides a basis to select interventions that are able to address a wide range of goals.

This methodology is therefore designed in such a way that it starts with a broad perspective and is based on stakeholders' goals, and the context is focused on specific interventions for selected product-market

combinations. In the postharvest assessment methodology described in this document, 18 steps are proposed, following the abovementioned considerations.

Postharvest assessment methodology steps

Once the focus of an intervention is clear, the current situation and bottlenecks and their root causes need to be assessed, as do market trends and climate parameters. Earlier interventions in the selected focus area, either in the country concerned or in international references, should also be assessed to learn from their results or failures.

The focus area of an intervention can then be classified as weak or strong on 11 related main criteria: resource potential, benefits for chain partners, policy & legal issues, knowledge, finance, markets, technology, input supply, logistics, storage, and processing & retail. This creates an overview of all the areas that need intervention, and this overview forms the basis for designing solutions. The overview is necessary to ensure that all aspects from the food system that might influence an intervention are covered.

The next step is a risk analysis for each proposed solution, combined with mitigation measures. This provides a description of the current situation plus advice to efficiently address bottlenecks and their root causes through policy implementation and provides the outcome of the postharvest assessment. As a result, partners have a good overview of the potential features of an intervention or policy implementation and its intended effect.

An intervention will likely take place on the level of the value chain (VC) or company. As such, the needs and potential contributions of the private sector involved in the intervention must be clear. An intervention strategy will be developed based om the outcome of a situational analysis. This Postharvest Assessment methodology specifically contributes to enhancing the strategic thinking of VC as well as food system (FS) actors and aligning their interests.

The market that the intervention focuses on needs to be assessed, as does the current food system, at the level of the primary producers, to obtain an indication of the level of sophistication of production technology and market (see graph 1, page 11). Accordingly, the appropriate postharvest handling or cold chain technology level can be determined.

Finally, it should be clear who is responsible to implement what actions and who is responsible for continuation once the intervention ends. This includes considering the spheres of influence of other actors in the food system that are related to the intervention's success. The resources required to influence and steer potential policies and actions needed to influence decision makers at the value chain level or in the enabling environment of the value chain must also be made clear.

Conducting a postharvest assessment this way can be done best as a combination of a desk study and field research. In our experience, this can be done effectively by an international researcher together with a local consultant. The main task of the international researcher is to meet the international standards while the local counterpart brings a good understanding of the local context, culture and language, all of which are important for practical reasons related to field research. Depending on the size of the interventions and geographical area involved, the assessment can be done by two persons or a team over a period of approximately two months.

Outcome: assessment of current PH chain and solid basis for strategic upgrade of PH chain

The outcome is a report that provides a clear insight into the current state of postharvest chains within a food system. This report can serve as a solid basis for policy interventions by governmental organisations and supply chain actors and help them to accelerate postharvest interventions for fresh products, resulting in a positive impact on the food system of their emerging markets. For most countries, this will be in line with the Sustainable Development Goals and/or national development policies.

If cold storage is a requirement, the PH assessment methodology provides insight into the required locations and capacities. The methodology also provides insight into the technical possibilities or impossibilities of different energy efficient technical solutions.

The outcome of the assessment can be compared to benchmarks on product yield, loss percentage, geographical area or organisation over time to get a better understanding of current performance and potential gains.

1 Background

This Postharvest Assessment Methodology is largely based on experience and knowledge obtained by the authors from completed and ongoing projects. Scientific publications and project documentation have also been used as reference material.

Postharvest handling – especially the B2B-part from harvest until supply to the consumer – is a focus area where huge amounts of perishable food are wasted on a global scale. With the food being wasted, so are the recourses used for its production and handling, like land, water, fertilisers, labour and energy. Improvements in postharvest handling therefore have significant impact on food availability for consumers. They also translate into limiting the resources used for food production per quantity unit. It is therefore an important field with respect to resource scarcity, growing populations and the associated increasing food requirements.

Postharvest (PH) handling is not a standalone issue: it forms part of food production and handling. As such, it is incorporated into food systems (FS) and value chains (VC). Successful interventions to improve PH handling depend therefore on a complex variety of factors and occasional conflicting interests on the part of stakeholders. Improving one issue may have negative or positive effects on other parts of the food system or be perceived as such by different partners. This is why it is important to understand the context of these issues and to assess this context properly in order to improve the success rate of interventions in PH handling and to ensure an effective contribution to the desired FS outcomes.

FSs include all activities, systems and processes related to food production, until consumption and waste disposal. This means that they include preharvest and postharvest aspects. Inputs needed and outputs generated throughout the different steps are also part of the food system. On the one hand, food systems are affected by social, political, cultural, technological, economic and natural environments, and on the other hand, they influence them simultaneously (see Figure 1). This also makes a food system suitable for approaches from either regional, country or global level perspectives.

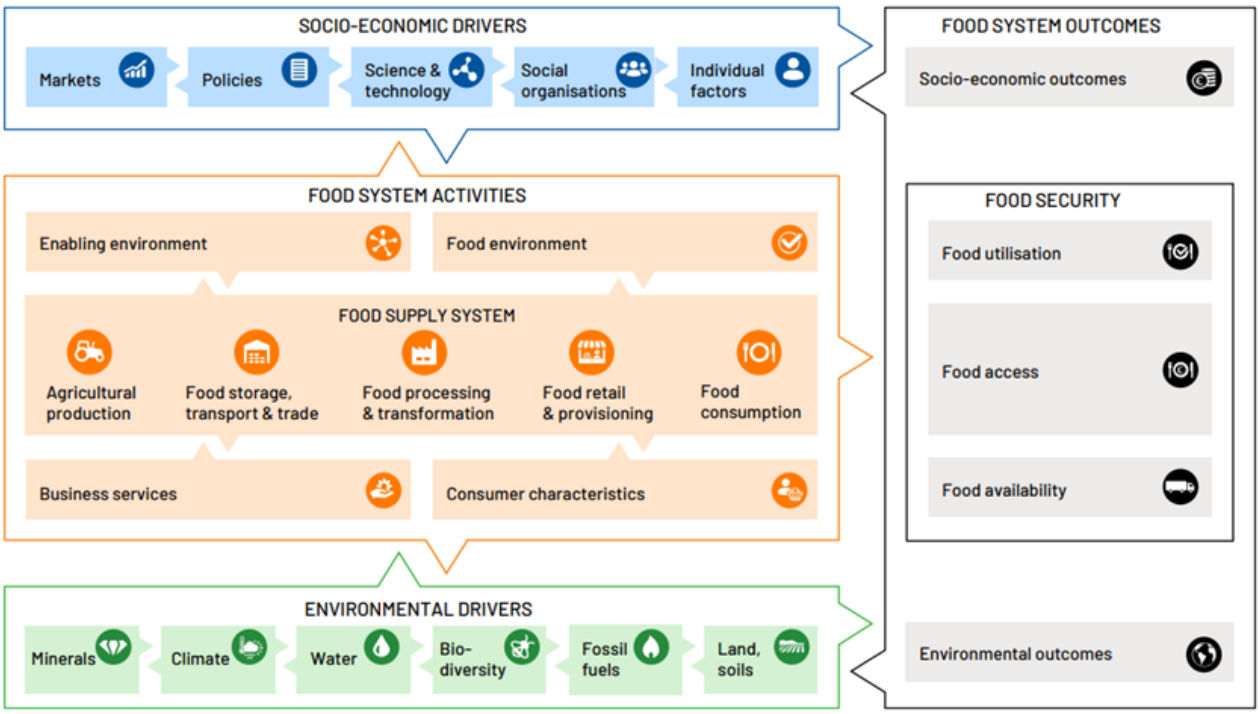

Figure 1 Food system framework – Source: Van Berkum et al. (2018)

Many value chains operate within food systems that are reviewed from a company level perspective. In this context, a value chain concerns a linear commercial business model in which companies cooperate based on profit, to produce food and add value to it, until it reaches the consumer.

Figure 2 Linear thinking versus system thinking - Source: 2018, V. Vernooij WFBR SCD

The steps needed for food production and distribution are mainly considered from a business perspective in value chains. However, value chains (VC) and food systems (FS) interact. The primary objectives of a decision maker at the company level (i.e., making profit) may well differ from a decision maker at a ministry of agriculture that seeks a wider goal, such as food security or import substitution, which are typical food system outcome issues. For successful interventions with sustained impact, it is important to ensure that the interests at the VC level are aligned with interests at the FS level.

In order to steer food systems toward specific outcomes based on policy objectives (e.g., reduction of food loss, mitigating environmental impact or improving food security and ensuring nutritious diets) interventions in the food chain itself are required. However, in order to avoid potential conflicting interests, negative side-effects or a lack of economic drivers at the VC level, an overall assessment of the PH chain within the FS is required. This results in a preliminary outline for the best approach to meet the goals set.

To conduct this overall assessment, a PH assessment methodology is of great value because such a methodology enables a structural approach of the assessment. As the assessment of food systems from a PH perspective requires multidisciplinary input, the structure of the methodology contributes to consistency of the quality of assessments, ensuring that all required perspectives are included.

The design of the relevant new PH assessment methodology needs to ensure that:

- It has a general structure that makes it suitable to use for a wide range of perishable products, crops and intervention objectives;
- To a large extent, the outcome does not depend on the persons that conduct the assessment;
- It provides insight into the FS improvement needs and the economic needs of the businesses' operations within this FS in order to be able to match these needs;
- It gives insight into where in the FS and VC decisions are made and by what means these can be influenced.

Food systems are not changed easily as a whole, nor should this always be an objective because it could disrupt existing livelihoods and businesses within the systems. Within the scope of this methodology we address specific bottlenecks while trying to avoid negative impacts and endeavour to stimulate positive effects elsewhere in the system.

A thorough assessment of objectives, types of products, current bottlenecks and their root causes, economic feasibility and the enabling environment results in a recommendation for an intervention, a policy implementation or project design with a high likelihood of efficient investments (location, hardware, size, knowledge), high impact on the foreseen policy goals per dollar spent, energy efficiency and impact continuation after the project ends. For example, if the objective of a government is to feed increasing urban populations with nutritious food, the purchasing power of these populations should be assessed as should the consumption patterns and the different national and international supply chains involved. A likely result would be the assessment and potential interventions focussing on fruit or vegetables that are widely consumed, have the potential to be grown in the country, and are part of a VC with room for improvement in production and processing. Improvement in PH handling will be of particular added value, using technologies that involve little additional costs to keep the produce affordable. If not assessed properly, an intervention with investment costs that are too high will lead to too high prices for the target group or it will be unable to compete with alternative produce or imports. Achieving high impact is also a key motivation to focus the assessment methodology on PH activities. While acknowledging the importance of and interaction with pre-harvest activities, in many LMICs big steps can be realised in PH, especially in reducing food losses. We also consider it desirable to focus on PH

instead of the entire production chain, in order to keep the assessment and recommendations manageable. Our PH assessment and intervention project experience has shown that zooming into the PH subsystem and identifying PH interventions creates benefits for the overall FS as explained before. Meanwhile, the same approach for developing a PH assessment methodology could be applied to assess primary production in a similar way.

With this report we seek to describe why a PH assessment methodology is useful, what areas it should assess to be complete, what the required steps are that have to be taken, and why. We also seek to describe the intended new PH structure and logic, based on which the interventions should be designed. We foresee the development of a methodology for PH assessment via a structural approach, aimed at providing insight into the requirements and interests of both the FS and the profit driven VCs operating within it. We describe subjects that need to be assessed for obtaining information on all aspects covering the FS under study and related VCs, as well as their interactions. For example, assessing the exact need for a cold chain in specific product/market combinations to avoid over or under investment.

In part, the Farmer-Led Irrigation Development (FLID) guide can serve as a source of inspiration for the PH assessment methodology, although this methodology only focusses on one topic (irrigation). This guide was developed by the World Bank and published in 2021 with a leading contribution by a colleague from WUR: Gert Jan Veldwisch of the Environmental Sciences Group (Denison & Veldwisch, 2021). The methodology of the diagnostic described in the FLID-guide is a particularly valuable example for the PH assessment when adapted for this purpose.

PH practices and requirements are influenced by pre-harvest activities, such as the need for storage versus irrigation in the lean season to improve product availability, and cost price and quality of produce at harvest in relation to destination markets, and preharvest technology level in relation to PH technology choice. The food systems assessment should therefore be regarded in a wider sense than just PH, not so much assessing the pre-harvest with the aim to improve pre-harvest activities, but rather including general pre-harvest issues for information as a starting point.

The PH assessment methodology can be used for all perishable products including dairy and crops like pulses, grains, root crops, and fruit and vegetables, fish and meat but with different focus areas. These will be addressed in this report.

In dairy, the postharvest handling is mainly focussed on raw milk cooling, collection, transport and processing. In grain, pulse and root crop sectors, storage availability and storage losses are major issues that have potential for improvement. According to Deepak et al. (2016), in LMICs, as much as 60% cereal grains can be lost during the storage stage due to technical inefficiency alone. Affognon et al. come to a lower but still substantial estimate (see Table 1). Of all perishable sectors, the fruit and vegetable sector may be the most diverse and complicated. Therefore, the assessment methodology is likely to be of the biggest added value. In the fresh fruit and vegetable sector, there is an additional factor that requires special attention. PH losses are often substantial, as indicated in the table below:

Product	Number of publications	Weighted average loss percentage
Mango	9	55,9%
Yam	7	41,6%
Cassava	10	40,4%
Tomato	8	33,7%
Sweet potato	11	27,2%
Fish	8	24,4%
Wheat	5	24,1%
Maize	73	23,6%
Cowpea	9	23,5%
Okra	3	23,4%
Irish potato	3	21,6%
Orange	2	18,8%
Rice	15	15,0%
Beans	2	14,0%
Milk	4	6,0%
Meat	10	2,6%

Table 1 Food loss % for selected crops in African and Asian LMICs - Source: Soethoudt et.al. 2021, Adoption of food loss and waste-reducing interventions in LMICs, WFBR

On country level, cooling is often seen as the number-one solution to address PH losses and quality issues. In a report on energy efficient cold storage for agriculture in Rwanda (Oostewechel et al., 2021), WFBR states that just assuming that this is the case in all circumstances often leads to investments in projects that are inefficient or result in 'White Elephants'; good quality facilities not being used after the project-end because of incorrect locations, cost-prices that are too high, a product/market combination that does not justify the investments, insufficient starting quality of the produce to be cooled, lack of maintenance of the equipment and/or the inability to keep the cold chain closed.

The choice for a cold chain, where one is required and in what part of the VC it should start, greatly influences the success of a loss-reduction focused intervention. At the same time, this choice has substantial implications for investment costs and impact per dollar spent, as well as on energy usage and carbon footprint. A thorough assessment of cold chain requirements provides decision makers with information they can use to motivate decisions in a structured way. This likely helps to significantly improve the intervention's success rate by determining the needs for specific product/market combinations, as well as identifying and mitigating risks. Assessing the need for a cold and/or ambient chain should therefore have a prominent role in the PH assessment in fruits and vegetables sectors. This includes the assessment of earlier interventions of similar projects and their effects.

2 Context, justification, goal, objective, scope and approach

2.1 Context for postharvest handling of perishables

There are many different value chains involved in agro-food production and its PH handling, with different drivers for the chain partners and operating on different levels of organisation and technological sophistication.

Some of the main contexts in which PH handling occurs in LMICs include:
- Subsistence farming plus surplus production for local markets;
- Commercial micro, small and medium enterprise (MSME) value chains focused on local/national markets;
- High value export crop VCs characterised by:
  - Large international companies with focus on high-volume produce and reefer transport (bananas, pineapple, mango, grains, pulses, vegetables like iceberg lettuce, broccoli, celery, etc.).
  - Low-volume produce exported by air (beans, snap-peas, asparagus, berries, etc.).
- Demand driven raw material supply chains for processing industry characterised by:
  - Large processing companies involved in freezing, drying, pre-frying, milling, canning (crisps, fries, sugar, vegetable oils, juice concentrates, flour, starch, dairy, etc.).
  - Small scale local processors with focus on local or regional markets (dairy, juice, snacks, half-fabricates for restaurants and food service, etc.).

It is likely that the technology levels deployed are adapted to the market and level of chain organisation and sophistication as visualised in the graph below. For successful interventions aimed at feasible improvements to the food system, this should be the primary consideration.

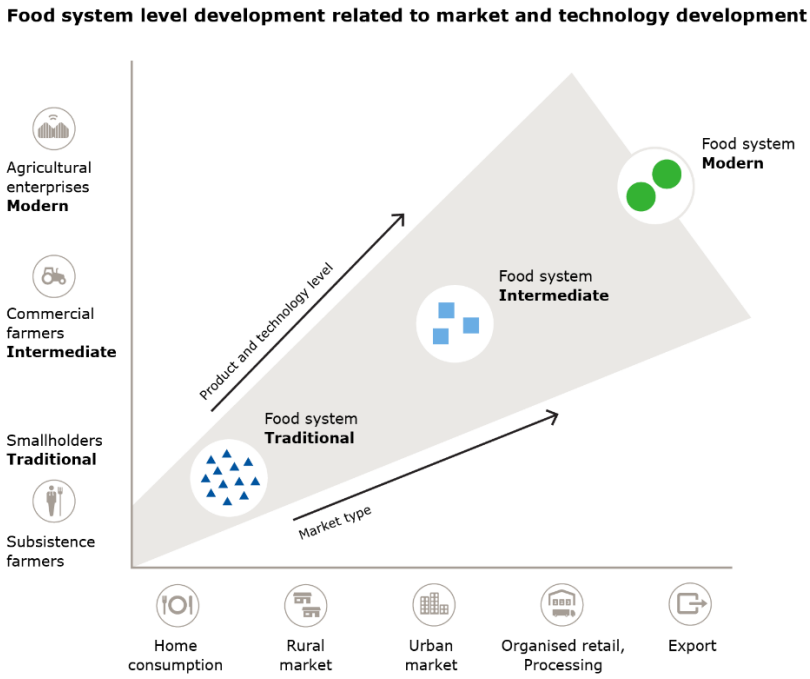

Figure 3 ***Food system level development related to market and technology development - Source: WFBR 2020, Postharvest interventions, key for improvement of food systems***

2.2 Justification for the postharvest assessment methodology

There are methodologies to analyse food systems (like The Food System Decision Support Toolbox (Posthumus H., Bosselaar J. & Brouwer H, 2021), and there are methodologies for assessing specific value chains. Often, value chains are also analysed based on the common sense of the consultant(s) doing the assessment. However, a methodology to assess the current situation from the perspective of postharvest handling – based on food system and value chain methodology, their interactions and how these processes can be influenced – is still lacking.

2.3 Goal and outcomes of the PH assessment methodology

The main goal of developing the PH assessment methodology is to provide practitioners aiming to assess current PH situations and design PH interventions with a methodology that enables them to select effective and efficient interventions in the field of PH handling, grounded in the complexity of a food system. The goal is to create impactful interventions for improving Food Systems (FS) and to assess the likelihood of their success. This methodology helps to incorporate the context of the FS and therefore increases the success rate of interventions, potentially having a positive impact on the FS. In this way, we provide a methodology that addresses PH assessment in a structured and complete way. Our goal is also to provide a methodology that standardises the diagnostic stage and makes its outcomes more objective and robust.

A successful application and practice of the PH assessment methodology is characterised by the following outcomes:

- An assessment methodology that provides clear insight into the current state of a FS, suitable for a wide range of perishables but specifically focused on PH handling. The result of the assessment is meant to form a basis for policy interventions by governmental organisations, developmental funding agencies and supply chain actors in such a way that it can accelerate PH interventions for fresh products resulting in a positive impact on FSs in emerging markets. In addition, it is anticipated that this FS impact aligns with policy goals as defined by governments and the Sustainable Development Goals.
- In the case of perishables that may benefit from cold storage, the PH assessment methodology provides insight into the required need, location and capacity of cooling systems. The methodology can also provide insight into the technical possibilities or impossibilities of different energy efficient technical solutions.
- The outcome of the assessment can be compared to benchmarks on the product, geographical area or organisation in time or the VC.
- The methodology is based on practical experience but will need validation through documented, practical case studies.
- Dissemination of the developed methodologies as a PH assessment approach is publicly available through a WFBR report.

2.4 Scope

The methodology must be able to serve the PH practice through three different purposes:

1. Allow PH innovators to assess the feasibility of a concrete intervention strategy, based on a specific product and/or region.
2. Allow PH innovators to assess the current situation as a basis for a pre-defined objective to be addressed.
3. Allow PH innovators to assess the current situation to determine points of interest for future pro-active policy development or other interventions.

The purpose for which the methodology will be used has an impact on how the assessment will be conducted. The purpose also has an impact on the diagnostics, and to what extent basic conditions are present to ensure an intervention can be successful. This is described in Chapter 4.

The assessment methodology can be applied for perishables in general, including dairy, pulses, grains, root crops, fruits and vegetables, meat and fish.

The assessment distinguishes four levels of analysis:

1. A conformation of the **purpose, scope and objective**:
2. At **regional or country-level**: the PH assessment methodology aims to assess the enabling environment in the FS, such as policies and public infrastructure that influence postharvest management of fresh produce. Targeted audiences for this methodology are regional and national governmental bodies. Non-profit organisations engaged in the broad development of LMIC can also use this methodology to analyse the feasibility of their financial or technical support to specific regional/governmental developments.
3. At **company-level**: the PH assessment methodology aims to access the PH chain from moment of harvest until final B2B destination, including available technology, knowledge and organisation. Intended audiences for this methodology are private sector companies, supply chain actors involved in the PH chain and trained extension workers.
4. At **influence-level**: the methodology gives an overview of the direct and indirect measures that could support the efficiency of an intervention or a policy implementation by creating conditions that influence decisions to be taken in value chains.

As a final part of the regional or country level assessment, a diagnostic will give an overview of strengths and weaknesses of the foreseen intervention (or combination of interventions) on 11 main resource fields (modules) related to it. The modules are subdivided in:

- Rationale for the intervention (two modules)
- Status of enabling environment (nine modules)

A risk assessment needs to form part of the preliminary advised intervention focus.

A business plan that includes the Social and Environmental Impact Assessment (SEIA) is required before investments are realised, but both business plan and SEIA are outside the scope of the PH assessment methodology.

Note that business plans are not only needed for private sector investments but also for VC or sector wide investments to perform an in-depth analysis of opportunities and risks, strategy, organisational and hardware needs, costs, benefits etc.

2.5 Implementation of the methodology

We structure the assessment as being a combination of a desk study and field research. As argued before, based on our experience, we strongly recommend a joint effort by an experienced international researcher and a local counterpart. The international researcher is tasked with meeting international standards while the local or regional counterpart provides a good understanding of the local or regional context, and the culture and language. After identification of the team the following implementation principles will be needed (detailed in the next chapters):

Conduct desk research addressing relevant publications and statistics.

Afterwards field research is conducted with interviews with all stakeholders, including decision makers at ministries and other governmental organisations, potential funding agencies, farmers and their unions, traders and service providers. The stakeholders that are required to provide information for the assessment are preferably chosen randomly to partly circumvent the occasional small groups of stakeholder representatives that may have strong ties to lobby groups, seeking subsidies and are often at the forefront but not always representative of the sector or VC.

The assessment must aim to yield strategic information about the current situation of the FS for which it is foreseen to design an intervention. It should aim to do so on a regional or country level as well as on company level. The assessment needs to describe the main weak points and bottlenecks in the current situation of postharvest handling plus the potential impact of possible interventions and end markets. Not just the bottlenecks, but rather their root causes in the FS environment should be described in this context.
The findings of the assessment serve as input to design a solution for each bottleneck that will be determined (on a country or company level).

Based on the focus area, local conditions, possibilities and limitations leading to a strategic set of recommendations, a diagnostic model will classify the focus area of an intervention as weak or strong on 11 main resource fields related to it.

After the assessment and solution design, the next step is a risk analysis for each proposed solution and combination of solutions, plus mitigation measures. Thus, the description of the current situation plus a recommendation to efficiently address bottlenecks and their root causes through policy implementation form the PH assessment's outcomes. This will provide a good overview of the potential features of the intervention strategy and/or policy implementation and its expected effects.

Optionally, selected key stakeholders representing the main different actors can be asked to comment on a draft version of the assessment report. Generally, validation of findings by representatives of key-stakeholders not only improves findings but also enhances ownership and shared engagement for the implementation phase.

Before moving toward an intervention or investment phase, additional reports may be required by specialised advisors. For example, a bankable business plan and a Social and Environmental Impact Assessment (SEIA) might be needed. These types of reports are beyond the scope of the present postharvest assessment.

3 Overview steps in the PH assessment methodology

This chapter provides a summary of all steps, which are detailed in the next chapter.

The foreseen assessment methodology comprises **Four** parts: objective confirmation, country or regional level, company-level and influence-level. The first part is followed by a diagnostic that indicates the strength of the current situation of the 11 main criteria/resource fields related to the intervention goal (resources potential, benefits for postharvest chain partners, policy & legal, knowledge, finance, markets, technology, input supply, logistics, storage and processing). This diagnostic results in a visual that combines the strengths/weaknesses into one overview. This visualisation helps to decide on interventions that address opportunities and risks.

Each part includes the following steps.

Part I: **Objective confirmation level**

During the first two steps, the assessment narrows down on the objective and (sub)sector/product(s) and provides insight into the current situation in relation to policy goals and development objectives, (potential) impact on food systems and risk mitigation.

Mostly the objectives are already formulated in a ToR but still it is important to re-confirm the objective as in practice it is often unclear and often a means to reach an objective has been included in the objective itself. The main purpose of a potential intervention should be mentioned and additional objectives can be added.

For example; It may occur that realising efficient cold storage is mentioned as an objective while the actual objective is to reduce food losses and/or improve nutritious food availability. Cold storage may be a means to achieve this, but not in all cases and often not without also tackling additional issues. Not clearly defining this step may lead to realising under-used infrastructure.

Another example is an objective to improve food availability in a country and supporting subsistence farmers and smallholders to realise this. In practice, improving food availability in remote areas or urban centres will require a different approach. In this case the target group(s) should be reconfirmed.

Step 1: Determine specific purpose and scope
Step 2: Assess the political/development objectives for the country/region

Part II: **Country-level assessment**

This part of the assessment is specifically relevant for decision makers at the strategic level within governments and financing agencies that are involved in development support. The country-level assessment consists of ten steps that are to be conducted in a logical sequence. These steps are listed below.

This part of the assessment leads to a preliminary outline for an intervention that best suits the formulated objective. It includes an assessment of potential impact and a risk assessment for potential failure and negative impact combined with mitigation measures.

Step 3: Assess the current situation for perishables in a country/region including bottlenecks
Step 4: Assess trends
Step 5: Assess the climatical issues to be considered
Step 6: Assess interventions in line with the foreseen intervention that already have been implemented in the past (if applicable) or compare with international examples
Step 7: Group the main bottlenecks and design possible solutions for each one
Step 8: Diagnostic of the rationale for the intervention (steps 1 and 2) and check the status of the enabling environment
Step 9: Preliminary outline for an intervention that best suits the formulated objective
Step 10: General risk assessment and mitigation

Part III **Company-level assessment:**

This assessment follows the country level assessment and is specifically relevant for decision makers within value chains but also for decision makers at a strategic level within governments and financing agencies that are involved in development support. It provides insight into the needs of the private sector involved in the potential interventions.

Step 11: Assess the market the intervention will focus on
Step 12: Assess food system level of sophistication/technology of primary producers
Step 13: Determine the level of knowledge and technology
Step 14: Determine which elements of the food system need additional assessment

Part IV **Influence and control assessment:**

This part of the assessment is specifically relevant for decision makers at a strategic level within governments and financing agencies that are involved in development support. It provides insight into how an intervention, or a combination of interventions could be supported by policy implementation and, as such, could be aligned with the interests of the private sector.

Step 15: Assess who is responsible for implementing actions
Step 16: Assess spheres of influence of other actors in the food system that are related to the success of policy implementation
Step 17: Assess means of influence and potential policies and actions to influence decision makers at value chain level
Step 18: Summary of the outcome of the assessment as the basis for interventions

An overview of the whole assessment methodology is provided in the box below.

Postharvest Assessment Methodology - summary overview

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Objective confirmation	**1 Scope**	**Example scope:** Concrete policy intervention/Pre-defined problem/Future policy development
	2 Objective	**Example objectives:** - Increased local food production/Feeding the cities - Food security and availability throughout the year - Improved nutrient rich diets - Improved income, employment - Food import substitution - Resilience to (international) supply chain disruptions - Resilience to climate change/Restoring Biodiversity - Restoring genetic diversity of crops as a means to food security - Restoring rural landscapes and/or erosion prevention - Food loss reduction - Water use efficiency - Development of a food processing sector - Export development / FOREX - Slowing down urbanisation rate - Circular agriculture objectives - Energy-efficient postharvest handling/storage - Protein transition (from animal to plant based) - Food safety - Gender and inclusiveness - ...

Country- or Region level	**3 Current situation**		Based on selected objective. E.g. distinguish between crops based on PH characteristicts and importance
	4 Trends & initiatives		Middle class development, export etc.
	5 Climate		Temperature, rainy seasons, elevations
	6 Previous interventions		Find Key Success- and Key Failure Factors
	7 Bottlenecks & possible solutions		Including application of ambient- or cold chain
	8 Diagnostic	**Modules**	
		Rationale for intervention	**(1) Resource potential**
			(2) Benefits for chain partners
		Status enabeling environment	**(3) Policy & Legal**
			(4) Knowledge
			(5) Finance
			(6) Markets
			(7) Technology
			(8) Input supply
			(9) Logistics
			(10) Storage
			(11) Processing & retail
			Criteria in relation to the objectives Rationale for postharvest Resource potential Benefits for chain partners Policy & legal Knowledge Finance Markets Technology Input supply Logistics Storage Processing & retail Enabling conditions very weak weak moderate strong very strong
	9 Outline for intervention		Based on gathered information, now formulate the intervention that best suits the formulated objective.
	10 Risk & impact analysis, mitigation		Including goals and potential negative side effects in the food system

Company-level	**11 Market assessment**	The market the business investment will focuss on
	12 Food system level of primary producers	Subsistence or commercial farmers? Size and number
	13 Determine technology level	Needs to match producer- and market development level
	14 Additional assessment need	E.g. water- or GHG footprint, SEIA

Influence & Control	**15 Responsible for actions**	Economic motives are main drivers for chain actors
	16 Influence by other actors	Economic motives can be influenced by public opinion, consumers, financers
	17 Policies to influence actions	E.g. tax, quota, subsidies, demands for financing etc.

Outcome	**18 Summary of assessment outcome**	Starting point for a business plan that details the sustainability and feasibility

Box 1 Overview of Postharvest assessment methodology

4 Country/region-level assessment

As explained above, the implementation approach of the assessment is a combination of desk study and field research. It may focus on a specific product, country or region. It may focus on a specific intervention that is foreseen or it may focus on a (future) problem or opportunity that is anticipated and needs to be addressed. The assessment will therefore follow a sequence of steps that are described hereafter. This sequence will remain the same, independent of the purpose of the assessment. Only the focus will differ with the purpose.

A country level assessment is a food system assessment. Its outcome can reveal the need for specific secondary policy development to support the success of the initial intervention policy aim. It can also reveal the need for infrastructure development. These outcomes need to be cross-checked in a company level assessment, as will be described in Chapter 6 (steps 11, 12 and 13).

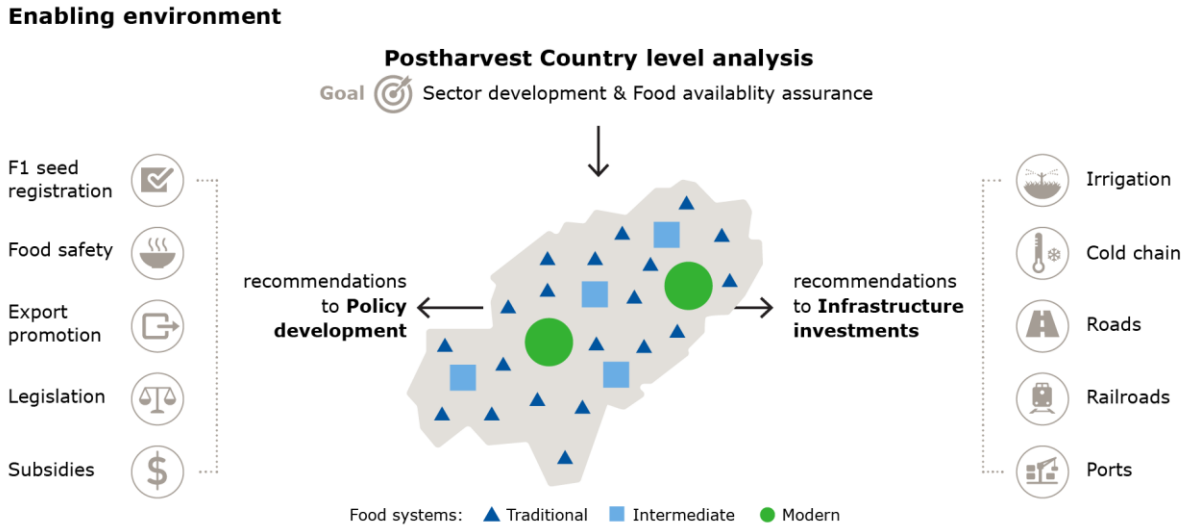


Figure 4 Country-level assessment - Source: WFBR 2020, Postharvest interventions, key for improvement of food systems

Step 1: Determine the specific purpose and scope

The methodology may be used for different purposes, and this needs to be clarified at the start with the client:
- To assess the feasibility of a concrete policy intervention idea, based on a specific product and/or region.
- To assess the current situation as a basis for a predefined problem to be addressed.
- To assess the current situation to determine points of interest for future proactive policy development.

Once the purpose of the assessment is known, the next steps in the assessment can be focussed on that. This assessment is based on the Terms of Reference or an interview with the client.

Example of a starting point:

A government of a developing economy is confronted with a rapidly growing urban population and sees food loss reduction in the fruit and vegetable sector as a desirable intervention. At the same time, the government wants to ensure that more nutritious food becomes available. They want to allocate funds to realise a cold storage infrastructure in the country and want to ensure energy-efficient cooling is installed.

Step 1: Determine specific purpose and scope

There is already a concrete policy intervention idea, based on a specific product. An intervention budget is known. The scope of this assessment is therefore to 'assess the current situation as a basis for a pre-defined objective' (option 2).

Step 2: Assess the objectives of the foreseen (policy) intervention

The outcome of the assessment of the objectives helps to determine and limit the scope of the next steps.

Interventions and/or investments in a sector may have one or several different objectives or a combination of objectives that differ in importance. These objectives mostly require a different approach and could include different optimal technologies or different preferred geographical locations for investments, and activities. It is therefore of the utmost importance to have a clear view on and a confirmation of the weighted objective(s).

This assessment is done by interviewing decision makers at the country level and reading relevant reports, supplied by these decision makers and/or from other sources. What policy intervention is anticipated? For what purpose, which target group or area and at what level of interference? Is a change in legislation anticipated? Are large impact policies planned or taking place? These could for instance include changes in international supply chains, or the consistency thereof, small scale project developments or large infrastructure investments in irrigation (rail)roads, regional developments or total sector restructuring.

The outcome of this assessment step needs to be verified and validated by the involved decision makers before continuing.

Examples of possible main objectives for interfering in perishables agricultural sectors include the following:

- Increased local food production/feeding cities
- Food security and availability throughout the year
- Improved nutrient rich diets
- Improved income with increased employment
- Food import substitution
- Resilience to (international) supply chain disruptions
- Resilience to climate change/Restoring Biodiversity
- Restoring genetic diversity of crops as a means for food security
- Restoring rural landscapes and/or erosion prevention
- Food loss reduction
- Water use efficiency
- Development of a food processing sector
- Export development / FOREX
- Slowing down urbanisation rate
- Circular agriculture objectives
- Environmental impact- and GHG reduction
- Energy-efficient postharvest handling/storage
- Protein transition (from animal to plant based)
- Food safety
- Gender and inclusiveness
- Spreading urbanisation over more nucleus areas
- Peri-urban food production
- Hygiene (waste handling or life animal slaughtering in urban areas)
- Other

This helps to narrow the focus area down to specific sectors or crops that need to be further assessed in the next steps.

Example:

Step 2: Assess the political/development objectives for the country/region

Interview with government representatives reveals that they want food security for the future urban population, especially catering for nutrient rich diets. Discussing a whole list of possible intervention goals reveals that apart from that, it is also important to achieve less dependency from foreign supply chains because of FOREX and the risk of supply chain interruptions. They also seek a mix between feeding cities and creating jobs because people need to have an income to be able to purchase food. Because of the impact they expect on energy use, energy-efficient technologies are preferred.

The outcome of Step 2 in this case is a confirmation of the objective of the intervention aimed at food security (major) but put in the right context that includes additional (minor) objectives.

Step 3: Assess the current situation for perishables in a country

Step 3 focuses on PH, and the assessment depends on the scope that was determined in Step 1 and the objective that was determined in Step 2. It can be narrowed down if the product or region are pre-defined or widened, if this is not the case.

As the PH situation is often related to pre-harvest issues, depending on the scope, some pre-harvest issues will be included in this step. These include assessing produce availability throughout the year, irrigation, product quality or yield levels (production costs), but only for informative reasons to determine the correct PH approach angle.

Grouping crops according to characteristics that determine their postharvest handling issues, including storage and cooling requirements.

Depending on the scope of the assessment as determined in Step 1 and objectives determined in Step 2, either the selected product-market combination needs to be assessed or an overview must be given of product characteristics as grouped below:

- Crops and their importance in consumption of the local population
- Distinguish between main groups of perishables with special characteristics (see below)

Dairy (milk)

Assess: number of farmers/cows, cooperatives, productivity, distance to collection centres, cooling capacity and availability, losses, demands of processors, supply difference between seasons.

Dry-harvested and oil crops

- Pulses; (groundnut, soybean, cowpea, bambara etc.)
- Oil; (sunflower, soy, palm oil etc.)
- Grains; (wheat, rice, sorghum, millet, maize etc.)
- Nuts and dates; (cashew)

Assess: Total production and/or consumption, storage systems, losses and their causes, location where losses occur.

Cause of losses	Location in the chain
rodents	farm/storage
birds	farm/storage
insects	storage
decay (fungal/bacterial)	storage

Table 2 Format for assessing the main causes of losses in dry-harvested crops

Root crops

- Irish potato, sweet potato, cassava, yam etc.

Cause of losses	Location in the chain
decay (fungal/bacterial)	storage
rodents	farm/storage
insects	storage
shrinkage (water loss)	storage

Table 3 Format for assessing main causes of losses in stored root crops

Assess: Total production and/or consumption, storage systems, losses and their causes, location where losses occur.

Fruits and vegetables

- Fresh market conditioning
- Medium- and long-term storage

  - Distinguish between temperate- and tropical fruits/vegetables (those stored close to 0ºC, a medium group stored at 6–9ºC and those stored at 10–14ºC).
  - Distinguish between climacteric fruits that ripen after harvest (allows harvest at early maturity stage) and non-climacteric fruits that do not allow for early maturity harvesting.
  - Distinguish in long-term storage to market produce in a different season and fresh-market cooling.
  - Distinguish between very-, medium- and low-perishability products.

Product	Ripens after harvest			Storage condition group				Storability				Perishability		
	Y	N	NA	Low 0-5 °C	Medium 6-11 °C	Mild +/- 13 °C	Dried	Not	Short <3 weeks	Medium 1-2 months	Long 3-9 months	Very	Medium	Low
Mango	Y					X			X				X	
Strawberry		N		X				X				X		
Potato			NA		X						X			X
Broccoli			NA	X					X				X	
Fava beans			NA				X				X			X

Table 4 Example of product characteristic grouping

Market analysis*:

** General assessment for the purpose of pre-selecting product/market combination. A more specific assessment focussed on the selected product/market combination will take place as part of the company-level assessment in Step 11.*

The following markets for perishables can be assessed, depending on the objective as determined in Step 2.

- High-end export markets (e.g., EU, US or Gulf)
  - Products and quantities exported from the focus country by air + destinations
  - Products and quantities exported from the focus country by reefer + destinations
  - Market developments and trends for focus products on selected markets
- Local/Regional low-end markets
  - Products and quantities consumed locally
  - Products and quantities exported in the region by truck + destination
  - Products and quantities imported to the country/region and origin

Sector analysis:

- What is the current structure of the sector and which VCs are covered in the sector?
- What quantities are available per product in the area?
- What are the average production levels (yield/ha)?
- What are the production systems/technologies?
- What are the farm-gate prices for product delivered from field or from store?
- What is the seasonality of farm gate prices?
- Is storage available, is produced stored, for how long and what are the used storable varieties?
- What constraints are there on development?

Assess the current postharvest losses estimate per crop (losses before reaching the consumer). For example, the top-ten focus crops that fall within the selected focus group (Step 2).
As available data is often limited at this stage, losses are to be estimated on an average level to determine in which crops and which part of the chains the biggest impact can be expected.
This can be done by conducting interviews with a random number of farmers and traders.
This step helps to select a sector and product where an intervention has potential for high impact if a product is consumed in large quantities and postharvest losses are substantial (see Table 1).

Example:

Step 3: Assess the current situation for perishables in a country including bottlenecks

In this step, the products the intervention will focus on are grouped as 'fruit and vegetables'. The market is 'Local market'. The reason for this is that fruit and vegetables contribute to a nutrient-rich diet. They can be consumed fresh or processed, and their cultivation and processing can potentially create many jobs.

The next step is to understand how big the local market is in terms of consumption (fresh and processed). What are the main fruit and vegetable types that are consumed locally? How big are the postharvest losses for these products and what causes them? Knowing these factors enables actors to focus the intervention on FS entry points where a large impact can be realised.

The sectors of the main products (e.g. top seven: banana, tomato, cabbage, mango, papaya, peppers, onion) are now assessed:

- What is the current structure of the sector?
- What quantities are available per product in the area?
- What are the production levels (yield/ha)?
- What are the production systems/technologies?
- What are the farm-gate prices delivered from field of from store?
- What is the seasonality in farm gate prices?
- Is storage available, is produced stored and for what period, and are varieties used that are storable?
- What are the constrains for development?

This assessment reveals the following for mango. Approximately 50% of the crop is wasted in the field because it is not harvested, it is severely affected by anthracnosis or it just falls from the tree. Somehow, there is not sufficient connection to the markets. On the other hand, the supply of mangoes in the urban areas does meet demand, but quality could be better and there is an approximate 20% loss between harvest and reaching the market. Some processed mango (juice, dried) can be found on markets and in stores. Consumers shift to other fresh fruit when the mango season passes while limited imports from neighbouring countries occur.

The following is revealed for tomato. Approximately 20% of the crop is lost in the field due to pests and diseases. The market always demands tomatoes, but there are two extended periods during the year when only imported tomatoes are available from a neighbouring country with a drier climate. Processed tomato products are found in abundance (paste, tinned, juice), but mainly from import sources.

Step 4: Assess trends and existing initiatives in line with the objective

Trends

It is useful to be aware of national trends that influence food systems. Important trends that have big impacts on postharvest activities include the following:

- Development of the middle class in a country
- Size of landholdings (do farms become bigger?)
- Midstream developments
- Development of a processing sector

The rise of the middle class is a particular driver for change in many food systems. It influences the demand for better quality fresh produce as well as for processed produce. It influences the sales price and margins that can be made. It also influences retail and the supply to retail (midstream). The development of the size of landholdings provides information on the level of logistical and technological requirements.

Existing initiatives

Existing initiatives may be grass roots initiatives by groups of farmers or value chain co-operations. Alternatively, these may concern running projects supported by government, NGOs or commercial investments.

It is important to understand what activities are already taking place in line with the foreseen policy intervention. Existing initiatives will confirm the trends and need for the anticipated intervention (or not).

Interviewing involved key staff may reveal the potential of the intervention and its impact on other aspects of the food system or reveal additional bottlenecks that need to be addressed.

Example:

Step 4: Assess trends

An assessment discovers that the middle class in the country is growing and, consequently, there is a growing demand for processed produce and some minimum quality requirement for fruits and vegetables. However, overall, consumers seek affordable calories and for fruit and vegetables, they seek relative cheap products and are willing to adapt consumption to availability.

Some specialisation can be noticed in traders becoming bigger and seeking chain cooperation with some retail buyers. They also seek cooperation with farmers to ensure consistency. Farmers, and subsistence farmers in particular, are a heterogeneous group in terms of farming activities, and many have side activities that often turn out to be main activities. For this reason, chain cooperation develops mainly between professional partners in MSME. Farmers that see farming as a business, invest accordingly: traders do the same.

This trend can be confirmed through assessment of the development of the size of landholdings and assessment of midstream developments and local processing.

An extensive assessment of potential for processed products is required. This concerns potential products to be made from available local production (e.g. mango), both as consumer products and half-fabricate for food service. The available (imported) processed products should also be assessed for type, price and potential to be replaced by local produce, if competitive.

Step 5: Assess climate conditions

For the climate analysis, there are several sources that provide information for the weather year-round, anywhere on earth. For example: *https://nl.climate-data.org* or *https://weatherspark.com*

This assessment provides information on day and night temperature which, in turn, gives insight on technology requirements for storing, cooling and handling. For example, in efficiency of evaporative cooling [1]. or the possibility to use night air for ventilation/cooling of root crops.

Rainfall gives insight into rain-fed cultivation seasons and related product availability. It also gives insight into available sun-hours per period, which can also be used as input for solar energy applications. Average temperatures are needed for insulation and cooling capacity calculations. Thermal amplitude – the difference between night and day temperatures – is important for some crops (such as potatoes), but it also has implications for cold storage potential.

Example:

Step 5: Assess climate conditions

The country has two rainy seasons: a main season and a short season. There are also two dry seasons in between. There are some differences in production seasons between different regions.

Irrigation is practiced on a small scale, especially for fruit and vegetable production. Still, most of the F&V production is rain-fed. A price dip can be noticed during the harvest periods when supply is abundant. There is hardly any storage for fruit and vegetables available, and it is only suitable for extending shelf life for a maximum of one week.

Fruit mostly have a single harvest window and are transported when price differences and availability justify it. Price information is not transparent, nor can consumers afford high prices. This limits availability to some extent. Consumers also change from one fruit to another according to availability and season.

There are no mountainous areas, so natural cooling/ventilation with night air is hardly possible. Sunshine is abundant but not in the main season when electricity is required for cooling.

Step 6: Assess previous interventions in line with the foreseen intervention

In many cases, related interventions in food systems or value chains have already been realised before. Some should be assessed in the case they are postharvest related. Experience teaches that assessing these interventions may yield very valuable information on the efficiency and effectiveness of the intervention in the short and long term. These interventions may be donor-funded projects, government initiated or commercial. They may concern interventions in the country to be assessed and/or international examples. They may have been successful or failures, or successful overall with some elements that failed. In all cases, the causes of success or failure need to be described and used for optimising future interventions. Key Success Factors (KSF) and Key Failure Factors (KFF) should be named and substantiated.

Example:

Step 6: Assess earlier possible interventions in line with the foreseen intervention

Some years earlier, four cold storage facilities were realised in the country within the frame of an international project aimed at reducing food loss in fruits and vegetables. Assessment of these interventions teaches us that three of the facilities are not in use anymore. The fourth is being used, but after reconstruction of the facility.

The main reason that the three facilities are not being used is because of operational costs, size and location. The vegetables that are harvested (tomatoes, egg plant, lettuce) can only be stored for limited time, so the main reason for cooling is to condition them to reach the market in better quality. However, the produce can reach the market withing 24 hours and remain in reasonably good condition during this period. No or hardly any additional price can be realised on the local market under these circumstances. Also, most consumers cannot afford to pay premium prices. The situation gets worse if a farmer does want to use cold storage: the facilities were designed for 100 pallets and need to operate for 20 field crates. The result is that it is not being used at all. One facility was close to the airport and suitable for cooling vegetables to be air-shipped to Europe. After adapting the capacity of the cooling equipment and the size of the cold rooms, this facility now suits its purpose. The vegetables (beans) need to be cooled before transport as a prerequisite, and the destination market is able and willing to pay a premium price that covers the operational costs of cooling and transport.

A Key Success Factor is a sound business plan that indicates that the sales price justifies the costs of the postharvest infrastructure; the availability of spare-parts and maintenance is another; and the correct capacity of facilities and equipment and having an available energy source is a third.

Failure is likely if cooling capacity is installed just for sake of installing it, without assessing the need for ambient- or cold chain handling for the product/market combination.
Failure is also likely if there is not enough produce in an area or only during a limited period. The facility costs, particularly investment related costs, are too high when calculated against the limited turnover.

Failure is likely if initial product quality is too low when supplied to postharvest/cold storage facilities. Postharvest handling efforts and costs can never be recovered from bad quality produce.

There has been an intervention to purchase tomatoes during the period of overproduction and low prices in order to process them into tomato paste. The initiative stopped after the intervention project ended. The reason for this was competition from very cheap tomato paste from China. Although local tomatoes were cheap, the factory could only produce paste for two eight-weeks periods. This resulted in operational costs being too high. Extended production periods required purchasing tomatoes from other areas and overlapping with periods when tomatoes did fetch reasonable prices in the market. In Italy, Portugal or China, tomatoes are grown especially for the industry. They use bush-types that grow without support, they spray ethrel to enhance simultaneous ripening of all fruits and have a mechanical harvest of over 100 tonnes per hectare. The yield level, which is 10 to 15 times higher than in our assessment country, plus the automated growing and harvesting, an extended harvesting period of several months and the large volumes that are processed, result in a raw material price that is very low.

Example:

Step 6: (continued)

The local tomato paste production simply was not competitive in a model that involved buying surplus from local farmers. The government could have interfered with import tax, however, they basically realised that the business model was not correct and also depend on China in other areas of the economy.

The Key Failure Factor is related to short period of availability for production and the cost price of the raw material (to a large extent related to yield levels).

Step 7: Group the main bottlenecks and their root causes and design possible solutions for each one

The previous steps gave extensive insights into the current situation, future perspectives and expected constraints, including climate and demographic dynamics. Based on this overview, a possible solution can be defined for the root cause of each bottleneck, possibly leading to an adapted strategy for an integrated PH policy intervention. In general, one of the relevant solution directions could have to do with storage loss reduction in grains and pulses. Another relates to investment costs and energy consumption per tonne of stored product for root crops and fruits and vegetables. The temperature control in the chains has already been discussed. A detailed description of Cold- and Ambient chain requirements in product/market combinations is part of the analysis as products and markets with different characteristics require different value chain approaches to be feasible.

Depending on the scope of the assessment as determined in Step 1 and objectives determined in Step 2, a description can be made per product/market combination as to what point in the value chain improvements and investments are required. These can include quality improvement at harvest moment; harvest handling; logistics handling and the cold chain.

Product	Market	Quality improvement at harvest	Harvest handling	Logistics handling	Cold chain Producer area Farm <1 hour	Cold Chain Producer area CC <5 h	Cold chain Urban area Wholesale <24 h	Cold chain local transit	Cold chain export transit Air - sea
mango	local	N	Y	Y	N	N	N	N	
	export	N	Y	Y	N	N	N	N	Y
strawberry	local	N	Y	Y	N	Y	Y	N	
	export	Y	Y	Y	Y	Y	Y	Y	Y

Table 5 Examples of intervention requirements for different product-market combinations

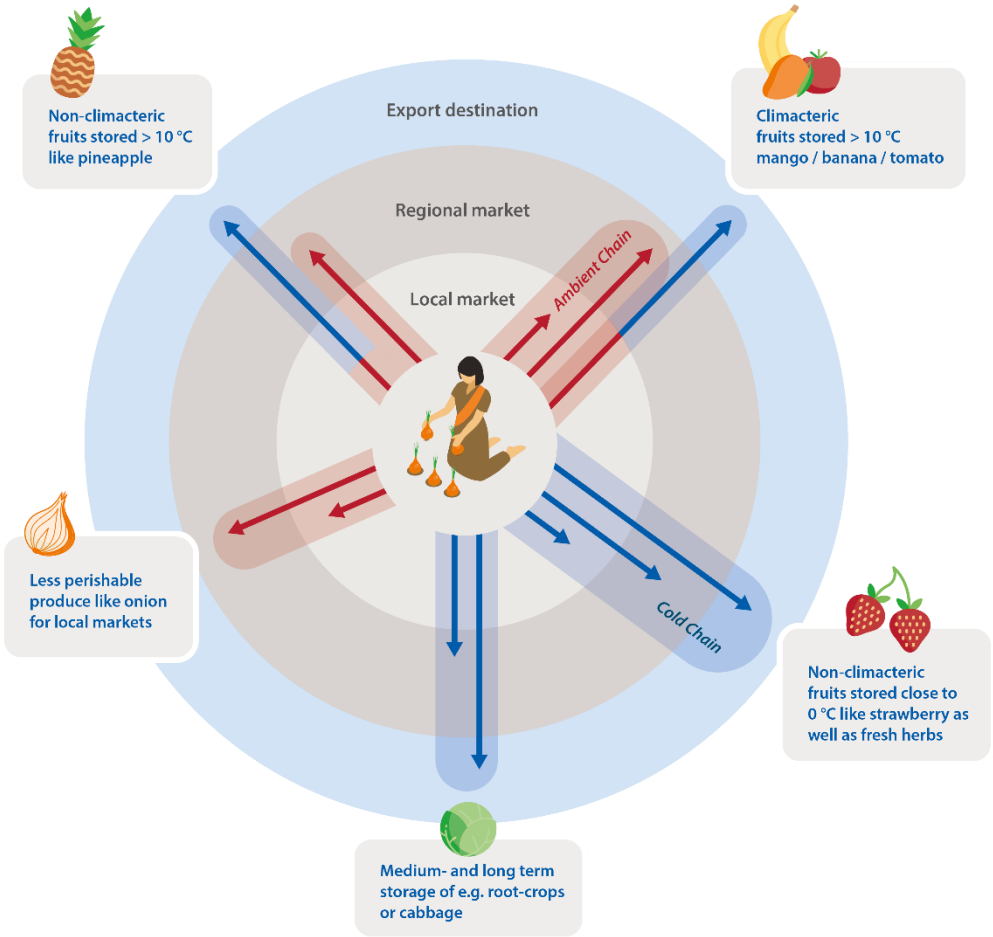


Figure 5 Ambient- or cold chain application for different product-market combinations - Source: 2022, R. Oostewechel, WFBR

Figure 5 shows that, sometimes, a cold chain needs to start directly after harvest (i.e., near the farm). In other cases, it is possible to start the cold chain after 12 to 24 hours (i.e., at a collection centre or further from the farm and serving more farmers. For some products to be marketed to a relatively close-by local market, a cold chain is not required at all, and loss-reduction can be better addressed by careful handling according to good practices, as addressed in standard operating procedures (SOPs).

The choices that are made, based on the specific need of the product/market combination, very much influence postharvest costs, economic feasibility, size and location of infrastructure and energy use. These choices also greatly determine the success of an intervention on the medium and long run. Other options may also be possible, depending on the purpose and scope as defined in Step 1 and policy objectives as assessed in Step 2. This may include extended product availability which, depending on the product, can include the necessity to assess potential to extend this availability.

In perishables, these alternative means may include:

- Optimising logistical handling and conditioning of fresh produce.
- Extending production seasons to prolong product availability through irrigation or protected cultivation.
- Short- or medium-term storage of (part of) the produce.

Conditioning of produce through processing (drying, pickling, making juice or concentrates) may include:

- Drying: Beans, peas, fruits, starch crops
- Pickling: Cabbage, cucumber
- Juice (concentrates): Fruits
- Freezing: Potato, fruits, vegetables
- Pressing oil: Avocado

For energy-efficiency objectives, aside from the need for cooling as assessed above, the technical design of the cooling equipment and its energy source need a special focus because not every energy-efficient solution will be feasible in all circumstances.

Example:

Step 7: Group the main bottlenecks and design possible solutions for each one

Assessing the losses reveals that they have several causes:
- Tomatoes, mangoes, plantain and banana, for example, are harvested when ripe, like farmers are used to doing for their own consumption of selling at the village market. For more distant markets, the harvest must be done in an earlier ripeness stage.
- Lots of pressure and abrasive damage due to handling in woven baskets or bags.
- Although harvesting is done in early hours, the time to reach markets is too long and produce may be exposed to sunshine or low RH (relative humidity) levels, causing shrivelling.

A major bottleneck is the short harvest window of mangoes and tomatoes in particular, and other fruits and vegetables to a lesser extent. This leads to peak production, low prices and a limited period of availability.

Another mayor bottleneck could be a lack of knowledge on when to harvest and how to handle the produce (a postharvest Standard Operational Procedure: SOP).

Available transport to the market and reliability of the availability resulted to be another, but the cause of that is related to the fact that farmers are also not reliable in requiring transport (no product or sold elsewhere).

Solutions can be found in product/market specific SOP development and training, harvest planning, alternative handling materials like field crates. Improved low-cost storage at the farm (e.g. evaporative cooling) enables flexibility in transport.

Alternatives to prolong the harvest window and therewith spread offer and labour requirements as well as limit price gaps, are tunnel production and irrigation.

Storage and processing can also be possible solutions. Storage for the vegetables we assess means spreading the offer with a maximum of two to three weeks due to shelf-life. For mangoes, as the trees and seasonal production are available, processing (juice or drying) could be interesting but would most likely require a combination with the processing of other fruits available during other seasons to extend the period of operation as much as possible for reasons relating to operational costs, labour availability and consistency in supply. More market research and business calculations to determine feasibility would be required prior to investing in this kind of intervention.

Step 8: Diagnostic

This step diagnoses the information that was obtained, resulting in an overview of strong and weak points. As this is the heart of the analysis, the diagnostic is addressed below.

Scope of the diagnostic

The diagnostic awards points to the rationale for postharvest intervention and indicates the enabling environment. This is based on 11 different criteria (or modules) that are explained in the next paragraph (modules).

Most importantly, the diagnostic needs to be adapted to the objective determined in Step 1 of the assessment.

The aim of the diagnostic is as follows:

- *To assess the feasibility of a concrete policy intervention idea, based on a specific product and/or region.*
- *To assess the current situation as a basis for a pre-defined problem to be addressed.*
- *To assess the current situation to determine points of interest for future pro-active policy development*.

The diagnostic must also give weight to the outcome of Step 2 (objective of the intervention). Therefore, one (or more) of the following objectives as determined in Step 2 must be taken as a basis for determining the potential for each module of the diagnostic.

Modules (criteria) for the diagnostic

The modules (M) are subdivided into:

- Rationale for the intervention (M1 and M2)
- Status of enabling environment (M3 to M11)

Rationale of modules for postharvest intervention in line with the objective

1. Resource potential. Meeting the objective of the intervention requires the availability of resources to contribute to postharvest development. Specifically, we refer here to natural resources related to the production of the raw material (climate, water, production seasons, harvest window, land availability). Resource potential related to storage and energy use are also important. These factors include sun-hours per season, grid network and the availability of height-elevations that enable natural cooling for potato storage or vegetables. The accessibility of producer areas, ports and (rail)roads should also be considered.

2. Benefits for chain partners. Chain partners must see benefits in the foreseen postharvest improvement intervention. These may be reduced losses, quality improvement, consistency in supply or quality, cost price reduction, handling efficiency, etc. In value chains, usually, the benefits must apply for all chain partners.

Modules enabling environment

3. Policy & Legal. With respect to postharvest handling, this concerns legislation regarding food safety, but also availability of phytosanitary inspection can be an issue. Tax incentives, property rights, investment protection as well as the safety of the location could be relevant.

4. Knowledge. Knowledge mainly refers to knowledge of the requirements of the market and other chain partners and the Standard Operating Procedures (SOPs) for postharvest handling. Knowledge can be obtained through communication between chain partners and via extension workers or consultants. Sometimes specific types of PH knowledge are not available in the current FS. This could result in the need to explore literature or new PH practices as conducted elsewhere in the world. It could also result in a PH research knowledge agenda.

5. Finance. Investments in postharvest handling or storage require financing. Not all banks see financing of agricultural value chains as their priority focus sector due to uncertainties in agricultural production and marketing. Collateral may be an issue if property rights are not described clearly. Specialists at banks should be able to understand business plans involving storage of agricultural produce. However, chain partners should also be able to develop solid business plans, including calculations and risk mitigation or seek advice for this.

6. Markets. The strength of a market very much determines the type of focus of the intervention. Export markets are the most demanding. Logistics to get there are a key focus point. International connections, customs handling, the reliability of transport, frequency, transport costs, local logistics to reach the international connection, available handling and cold storage facilities in harbour or airport, service providers (freight forwarders) presence should be considered. There is a huge difference in the logistics via air or via reefer transport, and the same is true for development possibilities within the sector. Competition in terms of price (labour, transport costs), marketing window, food safety and consistency of supply are other focus points.

Local markets are less demanding and less risky. Supply contracts for local processing are sometimes options.

7. Technology. The level of technology needs to match the market sophistication and its ability and willingness to pay premiums to justify investments made in postharvest handling improvements. If the level of technology increases, so does the need for maintenance as well as competences to handle PH technology. Energy availability and energy source are focus points. Availability of and need for cooling, capacity and location are also included in technology choice.

8. Input supply. Input supply concerns the availability of carboard boxes, cooling liquids, packing material and the like. It also concerns dealing with possible supply chain disruptions in the supply of seeds, planting materials, fertilisers, crop protection chemicals, etc.

9. Logistics. In postharvest handling, logistics are an important issue, limiting or offering possibilities. They concern local logistics (roads, (cold) truck availability, price per km, transport time) and international connections via air or reefer terminals.

10. Storage. Storage is an important issue in postharvest handling. It concerns availability, size, location, type in relation to losses, current losses versus potential ones, low energy storage potential, etc.

11. Processing and retail Processing may constitute a separate part of postharvest handling. The presence of a processing industry may be of special interest. The same is true of type, location, products, local or international focus etc. The processing industry often plays the role of driver for sector improvement.

Carrying out the diagnostic

In order to carry out the diagnostic, users should translate the assessment into a score from 1 to 5 for each module and justify this score in writing. This will result in 11 separate justifications for each objective. An example of this kind of justification is given below in Table 6.

Justification of the score		Score:	..
Objective:	Increased local food production/Feeding the cities		
Module:	1 resource potential		

Justification of the score		Score:	..
Objective:	Increased local food production/Feeding the cities		
Module:	2 Benefits for chain partners		

Table 6 Examples diagnostic score justification form

In order to create an overview of all strengths and weaknesses related to an objective for each of the criteria, the scores of each of the 11 modules (criteria) can be filled in an Excel file to produce a spider chart as follows (Figure 6):

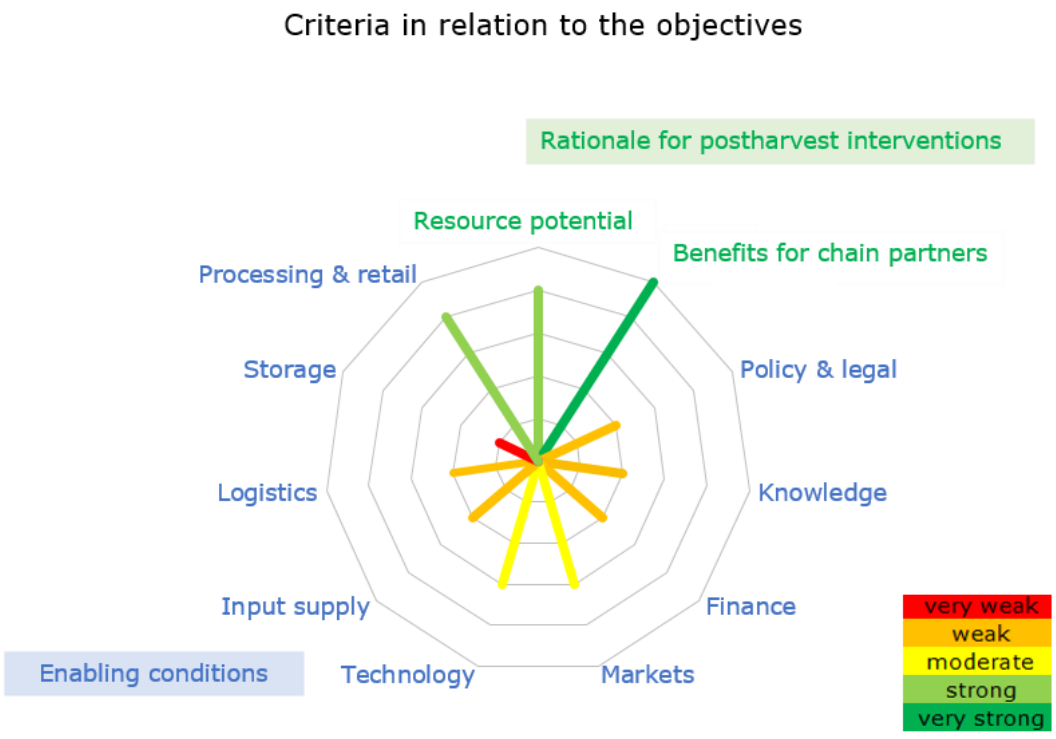


Figure 6 Spider-graph example showing visual overview of strengths and weaknesses

Example:

Step 8: Diagnostic

The diagnostic will be done on the objective of the intervention, in this case:

- Food security for the future urban population.
- Nutrient rich diets in particular.
- Less dependency from foreign supply chains because of FOREX and the risk of supply chain interruptions.
- Job creation.
- Energy-efficient technologies are expected.

A score will be awarded as follows:

1. very weak
2. weak
3. moderate
4. strong
5. very strong

Module 1: Resource potential. (score 4)

The production of fruits and vegetables in the country is substantial. Yield levels are relatively low, resulting in relatively high production costs per kilogram. Fruit quality at harvest is relatively good. Production, especially of fruits, is mostly rainfed, resulting in peak and lean seasons for availability. However, water resources and land suitable for irrigation are abundant. Yield levels could increase substantially based on climate and soils. Sunshine is abundant but not reliable enough to be the only source of electricity using solar panels.

Module 2: Benefits for Chain partners. (score 5)

Planning value chain supply from different areas and a combination of irrigation, tunnel production and storage is likely to increase the availability of fresh fruit and vegetables. The development of PH SOPs and the training thereof results in loss reduction. This planning is likely to be profitable for chain partners due to loss reductions and the strengthening of the position of midstream SME and SME farmers and profitability of the sector. This leads to professionalising of the sector and profits lead to investments and extending the activities. As a result, this contributes to feeding future urban populations while limiting dependency on foreign supply chains, reducing food security risks and FOREX needs.

Local SME processors of fruit and vegetable products, both half-fabricates as consumer products, would benefit from an intervention under which example chains organised that work on consistency of supply and quality. The same applies for retailers that need larger quantities for more stores (organised retail). Farmers benefit by the possibility to develop their business in line with chain partners and the market. Fixed chain cooperation results in a more secure income, which makes it easier to obtain external financing for business extension or improvement.

Consumers benefit via extended product availability and quality improvement.

The government benefits from a stable political situation due to cities being fed and jobs created. These result in less dependency on international supply chains and less need for foreign exchange.

Modules Enabling environment

Module 3: Policy & Legal. (score 2)

Food safety is currently unregulated by law in the country, nor is there a government agency dedicated to food safety control. We do not consider this a limiting factor, given the focus market. We do suggest including food safety issues, especially MRLs and HACCP, in the intervention without legal consequences for the time being.

Tax incentives and subsidies can be used to stimulate horizontal and vertical cooperation and chain integration by awarding these two entities under conditions of meeting chain demands like supply, turnover etc. or conditions of production scale for example.

Currently there is considerable import of cheap processed fruit and vegetable-based products. As many of these products come from China, which is a powerful partner of the country, and China has provided it with loans and infrastructure programmes, it will be difficult to block imports or increase import taxes. GATT agreements further limit the manoeuvring possibilities for the country in this field.

Module 4: Knowledge. (score 2)

An extension service is available in the country, but staff PH knowledge is limited, as is confidence in the farmers. Communication and training regarding SOPs and MRLs can best be organised via value chain partners (e.g. packhouse or Distribution Centre company/Cooperative).

Module 5: Finance. (score 2)

Local banks are not very interested in financing agricultural projects. Their staff seems to be less capable of judging business plans. Companies are not able to write sound business plans. Interest levels are 16%, no grace periods are offered and the pay-back time of loans is around six years.

Module 6: Markets. (score 3)

The local market can absorb many fruits and vegetables but, due to current peak seasons, supply occasionally exceeds demand, leading to rock-bottom prices and even unsold produce and waste. Alternatives for the fresh market that can take produce off the market would be welcome (e.g. cross-border supply to regional markets, processing, production planning).

Module 7: Technology. (score 3)

The food system is at a low level of development. This applies to retail, the midstream and farmers. There is development though, as landholding is growing somewhat and there is a tendency to concentrate on retail and midstream. The required technology should be adapted to this level. Careful business calculations are required, and improvements to higher levels of sophistication are foreseen in a later stage when the food system has also developed to a higher stage of sophistication.

Module 8 Input supply. (score 2)

Some new fruit and vegetable varieties would make a significant increase in yield levels possible. However, the government did not sign the UPOV-treaty and foreign owners of rootstock material are therefore unwilling to make their varieties available. On the other hand, imported vegetable varieties are not always available as the local seed institute blocks import permits.

The country does have K and P fertiliser available locally but depends on imports for N.

Crop protection chemicals are available but there seems to be a grey area of counterfeit illegal chemicals that are cheap but ineffective.

Module 9. Logistics. (score 2)

There are roads to all areas, but some areas are difficult to reach by truck during the rainy season. A selection must be made for regions with best potential and reliable road connections.

Transport costs per kilometre are high compared to neighbouring countries and international standards. This is likely due to the excessive power of the road transport union and/or agreements on tariffs.

There are enough trucks available in the country but none for cooled transport.

Module 10. Storage. (score 2)

Apart from the four cold storage facilities that were realised by an earlier intervention, there is no cold-storage facility available in the producer areas. There are some cold storage facilities in the capital that are only used for storing imported fruits and vegetables.

Module 11. Processing and retail (score 4)

The developing middle class in the country is a driver for development. Due to this development, organised retail starts to spread around the country. This leads to the demand of larger volumes of everything, including fresh fruit and vegetables. They also demand consistency in supply. The result is a need for backward chain integration, capable of meeting these demands. The same applies for processed produce supplied as product to retail or as half-fabricate to food service and restaurants.

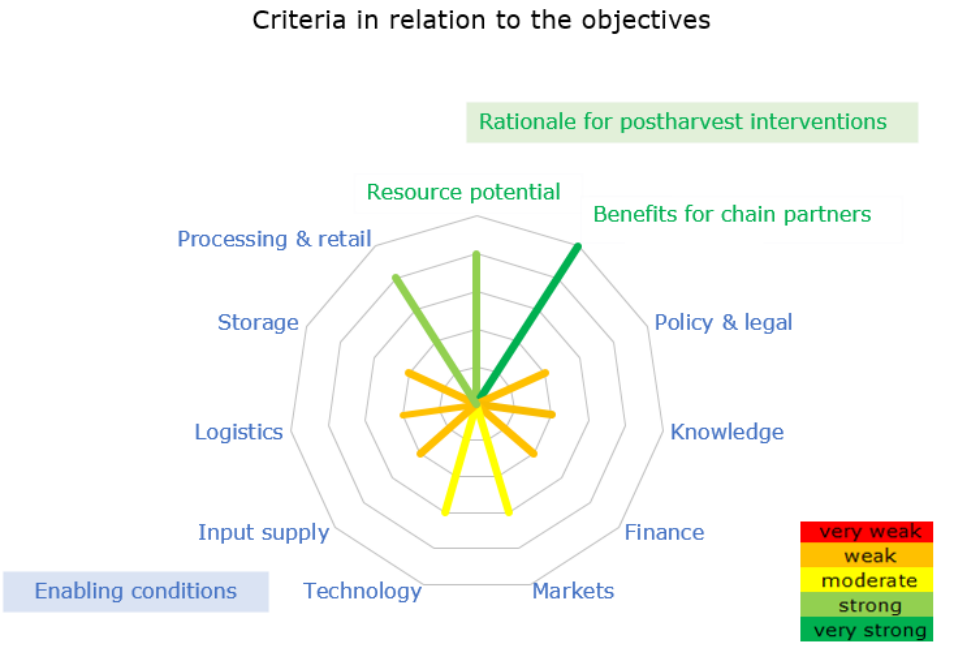


Figure 7 The diagnostic summarised in a spider-graph

Step 9: Preliminary outline for an intervention that best suits the formulated objective

Steps 1 and 2 determine the objective, and steps 3 to 8 yield information on how to **formulate the intervention** that best suits the formulated objective.

Based on the outcome of above assessments, recommendations need to be formulated. The intervention strategy will be developed based om the outcome of a situational analysis.

- The first step is to select a crop and region in combination with a target market that, together, have the best potential to realise impact and meet the objective(s).
- Second step is to select product/region/target market, focus on all weak points and bottlenecks in the enabling environment and suggest intervention measures that need to be included to strengthen the weak points and/or solve the bottlenecks.

Note that working systemically one intervention/solution might address various bottlenecks.

Secondly, a key message from FS thinking is that, in the past, symptoms (bottlenecks) were addressed, not the systemic causes of those bottlenecks. When bottlenecks are mentioned, these should be explained from a systems point of view! For instance: if a lack of skilled labour is a recurrent problem to operate cold chain facilities, a project should not only train a few people again, but invest in a new training/education module offered by an educational actor, organised together with a cold chain company to provide applied practical learning.

The justification of the scores as formulated in 4.3 can be used as a basis for grouping weak points and bottlenecks.

Selected product/region/market combination:		.....
Module (criterium)	Weak points that can or need to be addressed or opportunities to build on	Proposed intervention
Policy & legal	Food safety is an issue (MRLs)	Introduce HACCP training and implementation without official certification
Knowledge	Weak extension service with limited postharvest knowledge	Organise training on SOPs and MRLs via VC partners
Finance	High interest rates, short pay-back times make investments costly	Proper business planning substantiating technology level choice/ costs and pay-back potential
Markets	Peak production leads to low prices	Production planning, harvest season extending through irrigation
Technology	Low level Foodsystems but some developments to higher level	Chose mid-tech level and substantiate this choice in calculations
Input supply	Newest varieties not available. N fertilizer availability limited.	Advise government to seek UPOV membership. Intercropping with Leguminosae crops (inoculated) provides N to soils.
Logistics	Some areas do, others do not have reliable road transport access. Transport costs are high	Intervention locations in areas with access. Own transportation is likely feasible, Subject to calculation
Storage	No cold storage available	Focus on improved logistics and extended harvest window first in order to limit cold storage need. Limited capacity cold storage can be realised, subject to feasibility calculations
Processing	Middleclass development lead to slow increase in demand for processed products and half-fabricates for food service sector	Connection to developing mid-stream initiatives allows to jointly grow as Chain partners

Table 7 Format for proposed interventions

The assessment will describe the main weak points and bottlenecks in the current situation, plus the potential impact of a policy implementation addressing these bottlenecks from a FS perspective. These findings are used to design a solution to each bottleneck (on a country and company level) that takes the impact and influence of key actors into account. This report specifically contributes to enhancing the strategic thinking of VC as well as FS actors and aligning their interests.

The next step is a risk analysis for each proposed solution, plus mitigation measures. This will reveal difficulties in implementation, dependency on other policies or infrastructure for successful implementation or potential negative impact on other parts of the food system. Thus, the description of the current situation plus strategic advice to efficiently address bottlenecks through policy implementation form the outcome of the postharvest assessment. By taking this step, assessors have a good overview of the potential features policy implementation and its expected effect.

Optionally, selected stakeholders can be asked to comment on a draft version of the assessment report.

Before moving toward an investment phase, additional reports are required by specialised advisors. For example, a bankable business plan and a Social and Environmental Impact Assessment might be required.

Example:

Step 9: Preliminary outline for an intervention that best suits the formulated objective

From value chain perspective, availability of produce from different areas in the country and its alternatives must be mapped clearly. The supply must also be planned and organised for a full year.

These issues can be part of intervention design and must be included to some extent as they influence each other. The size, type and location of cold storage facilities must be carefully designed according to the needs.

The intervention should cover the full postharvest value chain from harvest to final B2B sale.

Example of value chains improvements that could be looked for:

- Covering the main eight fruit and vegetables (in consumption volume)
- Covering fresh market supply via wholesale markets (WSM as well as via organised retail)
- Covering storage (limited in time)
- Covering processing of F&V

Step 10: General risk and impact analysis and mitigation and/or adaption of plans

The identified FS solutions for bottlenecks and policy development and/or investment strategy derived from it are embedded in a wider context, building on opportunities as identified in the previous steps and addressing threats as well. A general risk assessment of the findings should therefore be included, and mitigation measures should be designed for each risk.

An impact assessment must be made for the purpose of the intervention, which was the outcome of Step 2 (potential positive impact) and for other parts of the FS (potential side effects or potential negative impacts).

The risk assessment must be done for risks related to achieving the goals set as well as for the potential negative impact on other parts of the FS.

Example:

Step 10: General risk assessment and mitigation

One general risk is a lack of chain cooperation and meeting obligations to either supply produce or purchase produce. Particularly in volatile markets, farmers tend to sell elsewhere when prices are high, and traders/processors tend to buy elsewhere when prices are low. For an intervention to work, long-term benefits must be clear. If this is the case, farmers can be removed as suppliers when not obeying to contract terms. Processors can be refused supply when not obeying contract terms.

Imports of cheap foreign produce may disrupt development of local production; for example, processed tomatoes that can be produced fully mechanically and cheaply. Competition with products like tomato paste should be avoided as trade measures to block import are difficult in this case. Rather seek opportunities in yield improvement, loss reduction etc.

Peak production (or limited availability) is a risk as consumers, retailers and processers seek consistency.

This can be mitigated via extending the harvest window (via irrigation), and crop planning.

5 Company-level assessment

The company-level assessment will be limited to an initial choice for feasible technology level and choice for a feasible size of operations, based on the figure below. The reason for this assessment is meant to indicate the best suitable market and technology level for stakeholders from a general perspective. A thorough assessment will take place within the frame of a business plan, which is outside the scope of this assessment methodology. The same applies for social embedding, sustainability and environment, which are also outside the scope of the assessment methodology, addressed in a SEIA as part of the business plan.

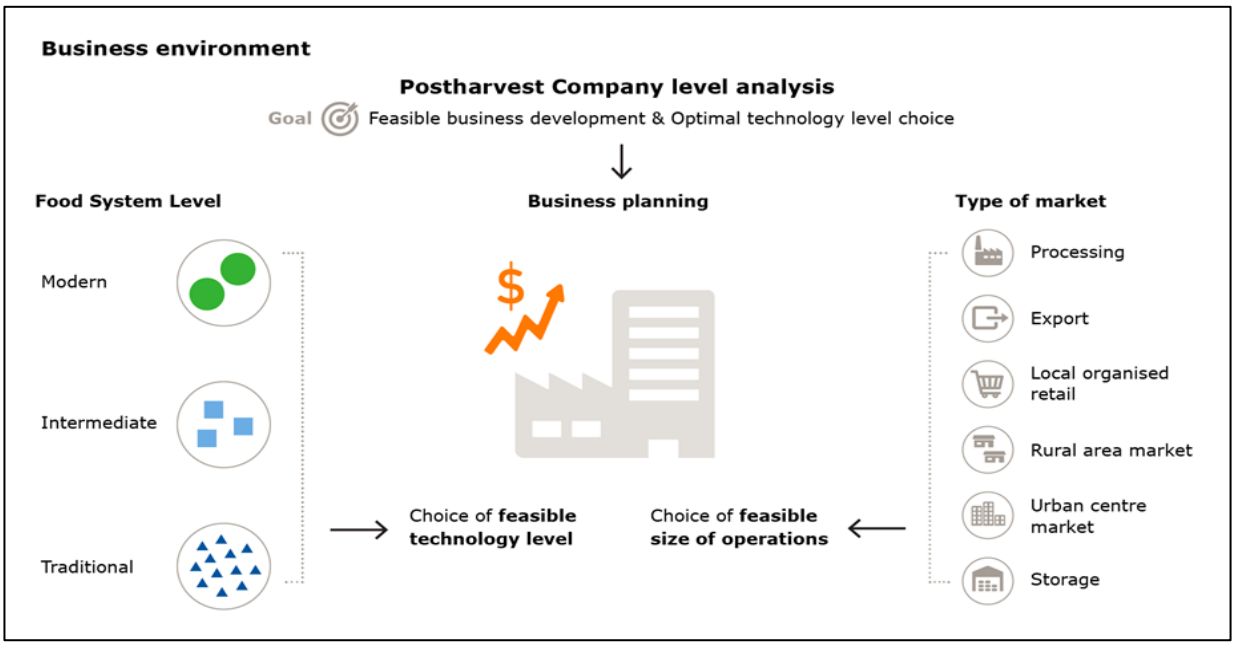


Figure 8 Assessment on company level - Source: 2020, Postharvest interventions, key for improvement of food systems, WFBR

Once this assessment is done, a business plan must be developed for the business to be set up. In paragraph 4.3.1, we have outlined what is included in these business plans, but the business plan itself is beyond the scope of the company level assessment.
Note that, within the framework of a project, an initial subsidy or grace period on interest and/or repayments is allowed, but the outcome of the business plan and calculations must show its feasibility after the project ends.

Step 11: Assess the market

Determine the market or markets that the project will focus on based on the policy goals of the investment. These can be local, regional, national or export markets. Each of these requires different postharvest handling and a different investment scale, to be detailed in the business plan (beyond the scope of the methodology described here). The market choice depends on farmer development level, location in the country, logistics, export potential, product quality and other factors.

Example:

This assessment follows the country level assessment and is specifically relevant for decision makers within value chains as well as decision makers on the strategic level within governments and financing agencies who are involved in development support. It provides insight into the needs of the private sector involved in the intervention.

Step 11: Assess the market the intervention will focus on

Several retailers and central market traders are selected to participate in the intervention. Their demands are assessed in detail regarding type of product demand, price developments throughout the year, and grading, packing, and quality demands, time and intervals of required deliveries and payment conditions.

Step 12: Assess the food system level of the primary producers

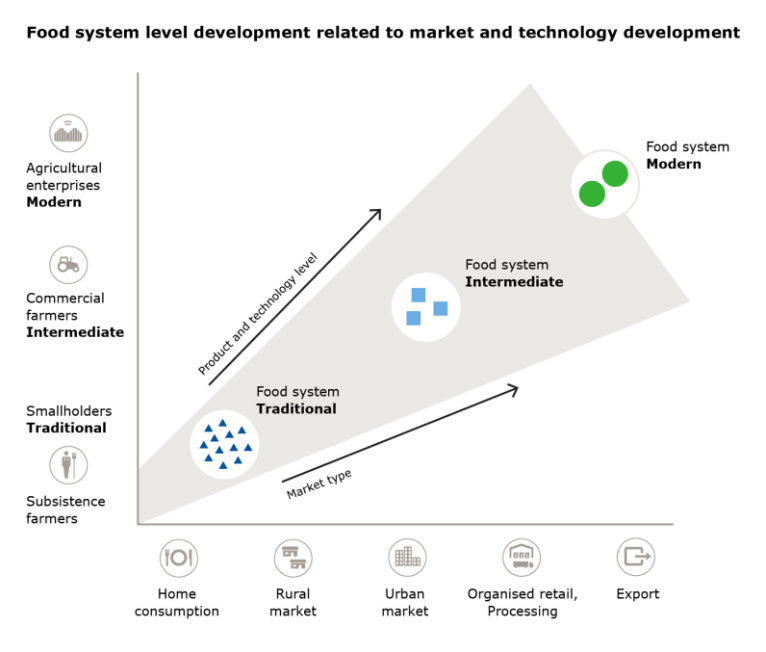
Determine the primary producer focus group; to what extent are they traditional, intermediate or modern entrepreneurs?

Example:

Step 12: Assess food system level of primary producers

The farmers in the selected areas that are involved in fruit production and those involved in vegetable production are mostly subsistence farmers who are 20–90% dependant on the income from their farming activities. Most have additional income as workers, taxi drivers, traders etc. A small segment of professional farmers has emerged that focuses on farming and focuses on growing enough to guarantee an income. The same can be seen in the midstream supply chain.

The intervention focuses on this last group, and this focus opens opportunities for others to also become professional and develop their business. For the moment, the level of development is moving toward an intermediate food system, as indicated in the figure below.



Also assess the availability of alternative fruits and vegetables during lean seasons in order to optimise the use of postharvest resources (labour, buildings, processing lines) for the obvious reasons relating to cost price and consistency. This needs to be done in detail in the business plan and calculations, prior to investment.

This step includes pre-harvest and postharvest. It is related to the market choice and determines the possibilities for postharvest handling and cooling.

Step 13: Determine the level of technology

This step includes the location, size and type of cold storage infrastructure is needed in case of fruit, vegetables or milk based on the model as presented in Figure 3. If applicable, it may include ventilation storage in the case of root crops; it may include the level of technology for processing, etc. An example is provided below.

Example:

Step 13: Determine the level of technology

The level of technology is to be mid-tech, avoiding cold storage when not needed and focussing on SOPs for correct harvesting and handling plus low-cost cooling at the farm. Only closer to the consumer area or market, during the last phase of postharvest handling -- for example at a retailer DC or processor storage of raw material -- the quantities are concentrated and sufficient to justify a higher level of cold-storage facility of handling equipment.

Earlier in the chain, a combination of mid-tech equipment like conveyor belts and abundantly available labour seems more suitable.

Additional costs relating to maintaining temperature requirements of fruit and vegetables, as well as the lack of cooled transport in the country are factors that influence technology choice and location.

Step 14: Determine which elements of a food system need additional assessment

A food system operates in and is influenced by social, political, cultural, technological, economic, environmental and natural environments. These may influence the performance of the VC and PH procedures and have to be assessed, either as a pre-requisite for the intervention, or as a demand for financing. An example is given below.

Example:

Step 14: Determine which elements of the food system need additional assessment

Water use efficiency and gender equality are issues that likely need additional assessment. However, we advise having a SEIA made as an annex to a business calculation and using the outcomes of the SEIA to determine the need for these FS elements.

6 Influence and control assessment

For the successful implementation of an intervention or investment, the interests of the partners need to match the FS interests that are usually the basis for the intervention. In order to ensure that these interests align, the first step is to assess where the power lies amongst the VC actors to do so. In other words, who is in control of making decisions, which resources do they control, and what mechanisms are in place to ensure they can influence decisions?

This part of the assessment methodology helps to pinpoint what intervention objectives can be supported, and by whom. This concerns the food system (country/regional level), the value chain (company level) as well as their interactions. The next steps provide guidance on how to assess these elements.

Step 15: Assess who is responsible to implement actions

To assess the direct and indirect measures that could support the efficiency of an intervention or investment implementation, an assessment that is focussed on the key actors and the decision-making process is required.

The starting points are:

- Objectives for interventions mostly concern the perspective of Food Systems (FSs)
- Implementation of interventions is mostly done via Value Chains (VCs)
- Policy is the main driver for food systems
- Profit is the main driver for value chain actors
- For successful interventions, policy objectives must be translated into economic drivers for value chain actors
- Pressure of governments, financial institutions and/or (consumer) pressure groups can directly or indirectly influence the economic drivers of the value chain.

In the following figures is explained how in local- and international settings, value chains can be influenced to reach policy goals.

Local- and international pressure groups interact with consumers and at the same time influence policies from governments as well as organised retail and financing institutions. Pressure groups often respond to societal concerns, such as environmental or labour conditions, etc. International governments may translate the message of pressure groups into (import) legislation. Retailers demand certification, transparency and traceability from suppliers. Banks are very sensitive to possible negative publicity and set pre-requisite conditions for financing projects and businesses to avoid negative social- or environmental impact of the intervention and their liability for financing it. In international settings, pressure groups are often stronger and their influence is bigger. Also consumer are likely somewhat more demanding, but basically the pressure and influence works the same way in international (see Figure 8) and local (see Figure 9) settings.

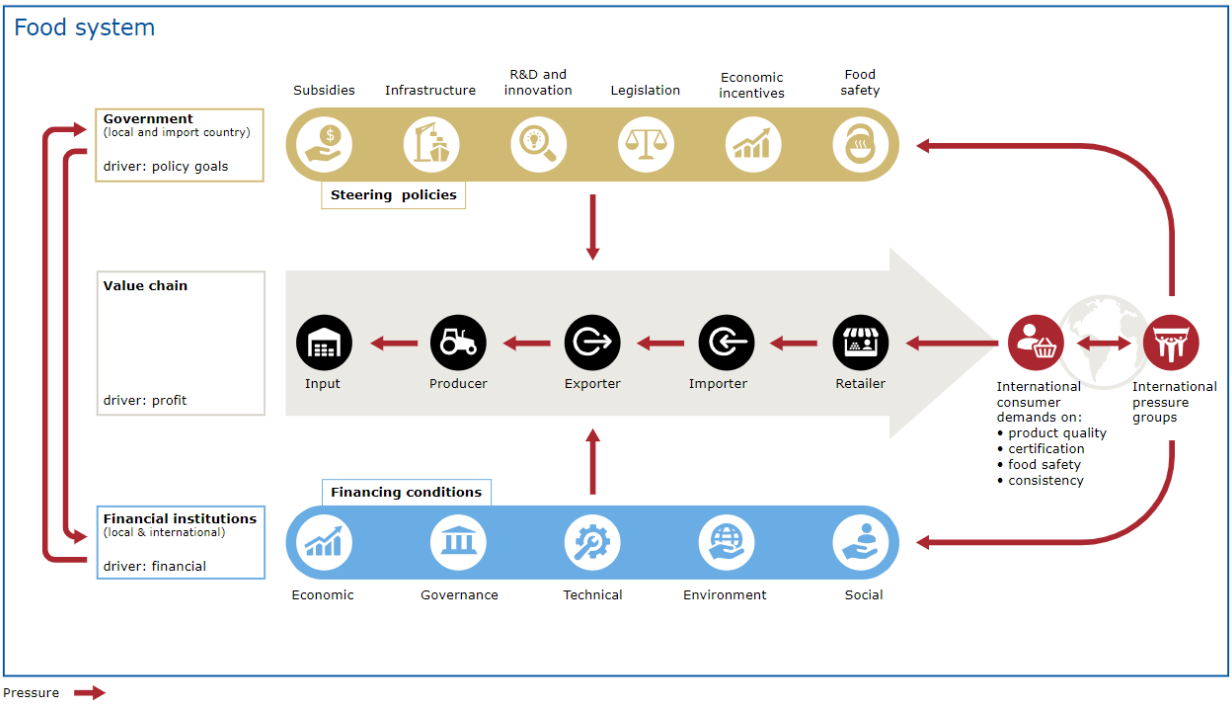


Figure 9 ***How international chains can be influenced to reach policy goals – Source: WFBR 2022***

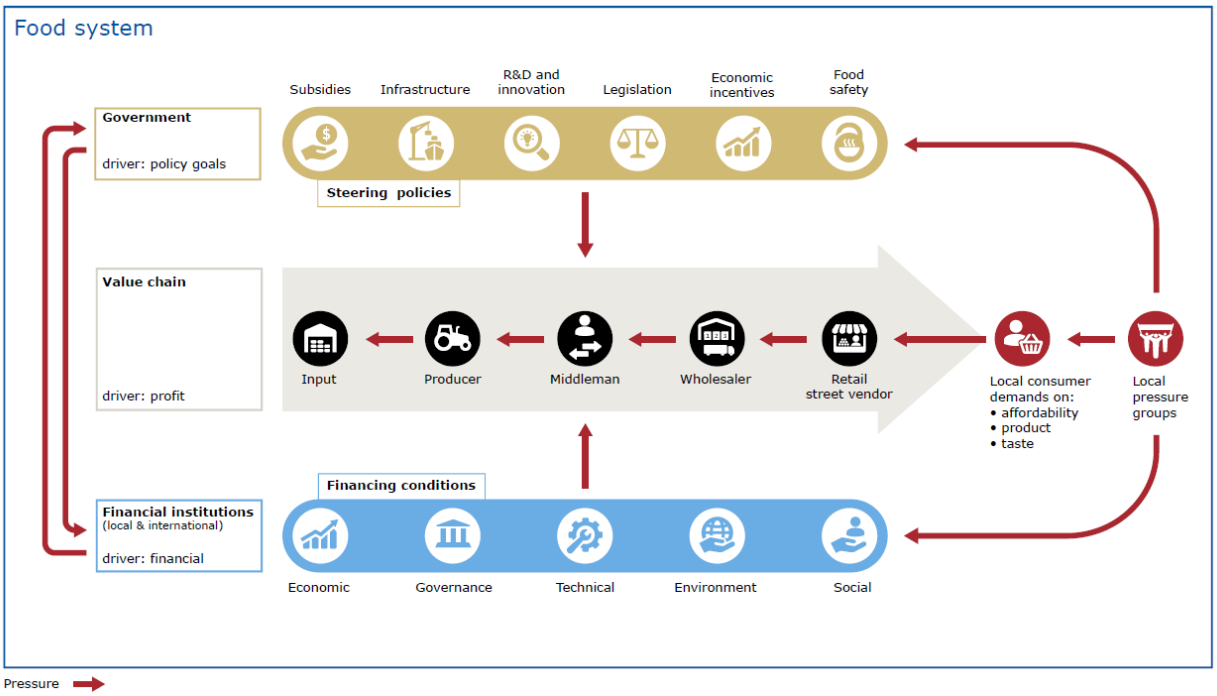


Figure 10 ***How local chains can be influenced to reach policy goals - Source: WFBR 2022***

Local governments of the country where an intervention is planned, have several tools to influence the economic parameters for value chains, so called steering policies. These are mainly focused on influencing potential profitability of a Value Chain intervention via taxation or subsidies. Also investments in infrastructure may facilitate the performance of Value Chains, as does extension and legislation. Market regulation like quota and import tariffs also influence availability and price of products and therewith influence profitability and thus influence decisions made in these chains.

When designing interventions, concrete supportive policies for the enabling environment, especially at the level of local government policies and intervention financing conditions can be suggested by the consultants. These should be substantiated by indication how the proposed supportive policy influences the value chain decision maker and to what extent it is needed to contribute to the success of the proposed intervention.

Example:

Step 15: Assess who is responsible for implementing actions

This assessment is specifically relevant for decision makers on a strategic level within governments and financing agencies involved in development support. It provides insight into how an intervention can be supported by policy implementation and as such can be aligned with the interests of the private sector but also interest of consumers and the environment.

Farmers are responsible for producing crops

Traders/packhouses are responsible for communicating postharvest SOPs to farmers.

Step 16: Assess spheres of influence of other actors in the food system

Other players, like governments and international organisations, may have wider goals for food systems in which value chains operate, such as import substitution, food loss reduction, nutritional diet improvement, protein production, energy efficiency and environmental protection. In almost all cases, they need the private sector to reach their goals.

The only way to achieve this is by assuring that legislation and market requirements are adjusted in such a way that it is in the private sector's interest to adapt their policy and get the best economic returns. The government has the power to directly influence the appropriate legislation and tax incentives. Financers have the power to set conditions for business models prone to financing. In export markets, importers also have this power. International organisations and pressure groups representing consumers or environmental concerns have some power to lobby or influence governments or retail organisations, so they move in the direction preferred by these organisations/groups (medium and long-term influence).

Of course, the private sector will also give feedback on specific requirements if so needed, for example on pesticide regulation and seed registration. However, this is left out of this assessment as it will likely be a natural response.

Example:

Step 16: Assess spheres of influence of other actors in the food system that are related to the success of policy implementation

Organized retail and processors demand standardization on size, quality, packing, grading and food safety.

Step 17: Assess means of influence and potential policies

Food systems and specifically the value chains that operate within them are or can be influenced by different actors and from different angles. In most FS these are the following:

- Public opinion
- Economic/financial incentives
- Tax incentives
- Legal (import) demands on food safety (HACCP)
- Chain liability issues (each higher step demands compliance by its supplier)
- Market demands
- Financial institutions demand for financing
- Availability of infrastructure

The economic incentives for decision makers in a VC can be influenced in a variety of ways. For example, if public opinion in the target market cares for sustainable production, this may lead to a rejection of produce not certified as such. This results in an economic incentive for the value chain to comply.

Another example could be the demand by financing organisations that a SEIA is a condition for the loan-approval process. This results in an economic incentive for the company involved to comply. Tax incentives may stimulate investments in certain sectors. These could result in economic incentives for companies to invest. Import legislation is often in place on MRLs and food safety issues. These rules may become stricter.

In this step, as many means of influence should be summarised as possible.

Example:

Step 17: Assess means of influence and potential policies and actions to influence decision makers at value chain level

In the value chains developed as main part of the intervention, farmers are responsible for the production of the crops during the agreed period and for producing the agreed quantities. They only do so if they believe in profitable business. The government does not have much influence on prices but could guarantee minimum prices for produce supplied according to agreement if the market price drops below a certain minimum level.

Step 18: Summarise outcome of the assessment as a basis for an intervention

The country-level assessment resulted in a preliminary outline for an intervention that best suits the formulated objective (Step 9) and a risk assessment.

The company-level assessment adds foreseen markets and technology level choice, and the influence assessment adds possibilities to influence the enabling environment and economic parameters that may be required or helpful to align value chain interests with food system-level interests; in other words, to ensure the business case of an intervention is economically feasible.
Step 18 results in an outline for an intervention that can serve as a starting point for a business plan, which details the sustainability and feasibility of an investment foreseen as part of an intervention (see Annex 1). Another part of the intervention may focus on the enabling environment.

Example:

Step 18:

Food security and nutritious food for local market is required. The objective is to achieve this by investing in cold storage to reduce waste. Whether this is the right strategy needs to be assessed.

The biggest impact would be achieved with the eight main consumed locally fruits and vegetables. The yields of these can be improved, and postharvest food losses are quite high. There is potential for impact.

The growing middle class and increasing farm size indicate that retail and processed products will increase in market share. This stage of development most likely requires mid-level tech solutions and value chain development.

Banana is available year-round, mango three months per year and vegetable crops two periods of two to three months. For each of the eight crops, the availability throughout the year must be clear, rainfed, irrigated, different production areas etc. Possible storage requirements can be determined from this.

Earlier investments in cold storage are mostly not used currently due to location, capacity, lack of product, too high operational costs, limited period of use and lack of chain involvement. These mistakes must be avoided and learned from in the design of the intervention package.

For each of the eight products, it must be determined where the cold chain should begin and what measures can be taken to reduce losses during the first part of the chain. As no cooled transport is available in the country, it is likely best to work with an ambient chain until reaching the consumer area in order to avoid wasting energy and incurring costs on produce if the cold chain cannot be kept closed.

We propose to develop VC pilot projects for each of the eight main crops. Stimulate cooperation and focus on consistency in supply and quality. Cooling will likely be part of these chains but not a pre-determined condition. Work back from the market (retail) to meet requirements (maximum price, quality levels, supply windows etc.), design the supply accordingly with the market demands as starting points, and making use of extended harvesting windows (improved handling, earlier harvesting, etc.) is also required. Once a proof of concept is clear, the same approach via retail and/or processors must be taken by including pilots for processed products, preferably based on the eight main crops as sources of raw material.

The government must be included to make pilots successful by addressing the main enabling environment issues that resulted from the assessment (e.g. knowledge and extension).

This backward integration VC pilot approach is likely to also reveal additional focus points for improvements in the enabling environment. Part of the budget must be reserved for solving these issues at a later stage. For this reason, the government, as well as other relevant actors like e.g. service providers, research, knowledge/education centres must be closely involved in monitoring the implementation of the pilots.

7 Recommendations and implementation plan

This chapter refers to the postharvest assessment methodology development and its implementation.

We recommend working out the structure for the methodology as described in this paper. This includes the development of supportive materials, such as:

- Standard examples and questions to choose from for each of the 18 steps of the assessment.
- Standard examples and questions to choose from for each of the 11 modules (criteria).
- Examples for solutions for the main bottlenecks and weak points for each of the 11 modules (criteria).
- Benchmarks for the different product(groups) and geographical areas related to food loss during postharvest handling and food loss during storage and organisation in postharvest handling time and chain.
- Benchmarks and assessment requirements regarding technical requirements and pre-requisites for various energy-efficient postharvest handling and storage solutions.

There are many areas for which the methodology can be used. Narrowing down during the first two assessment steps helps to focus and determine the scope of intervention. However, **the methodology needs validation** by being used in practice in two ways:

- To confirm its suitability for the intended different purposes as mentioned in terms of scope (Step 1):
  - To assess the feasibility of a concrete policy intervention idea, based on a specific product and/or country or region.
  - To assess the current situation as a basis for a pre-defined objective to be addressed.
  - To assess the current situation to determine points of interest for future proactive policy development or interventions.
- To confirm its suitability to address the main objectives for intervention as mentioned in Step 2.

Adaptions to the methodology may result from the validation process. For instance:
- Additional information may be required, leading to additional questions.
- Unreliable data and information might require triangulation
- The choice of actors to interview must be reviewed to see whether they are representative of the sector, leading to an adaption or confirmation of the participants representing public and private stakeholders. Or new actors are to be added, for instance from the enabling environment. Representation may be incomplete or imbalanced, requiring adaptation in terms of identifying other actors.
- Crops or sectors may need to be skipped or others added resulting in the need to skip or add sector specific questions.

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