Roadmap Post-Harvest Loss Reduction in Selected Vietnamese Value Chains

Phase 2

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This study was carried out by Wageningen Food & Biobased Research and subsidised by the Dutch Ministry of Agriculture, Nature and Food Quality.

Wageningen Food & Biobased Research
Wageningen, September 2022

Public

Report 2330
DOI 10.18174/577022

WAGENINGEN
UNIVERSITY & RESEARCH

WFBR Project number: 6239195801
BAPS number: BO-43-113-023
Version: Final
Reviewer: M. G. (Melanie) Kok MSc
Approved by: dr.ir. H. (Henk) Wensink
Carried out by: Wageningen Food & Biobased Research
Subsidised by: the Dutch Ministry of Agriculture, Nature and Food Quality
This report is: Public

The research that is documented in this report was conducted in an objective way by researchers who act impartial with respect to the client(s) and sponsor(s). This report can be downloaded for free at https://doi.org/10.18174/577022 or at www.wur.eu/wfbr (under publications).

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Contents

Acronyms

CA	Controlled Atmosphere
DFC-1	Dragon Fruit Company 1
DFC-2	Dragon Fruit Company 2
DFC-3	Dragon Fruit Company 3
DIP	Dutch Input Provider 1
DTP-2	Dutch Technology Provider 2
DTFI	Dutch Tropical Fruit Importer
DTS-1	Dutch Technology Supplier 1
DTS-2	Dutch Technology Supplier 2
EKN	Embassy of the Kingdom of the Netherlands
FL	Food Loss[1]
FLs	Food Losses
FLW	Food Loss and Waste[2]
FW	Food Waste[3]
G0 seed potato	Generation 0 seed potato[4]
G1 seed potato	Generation 1 seed potato[5]
G2 seed potato	Generation 2 seed potota[6]
G3 seed potato	Generation 3 seed potato[7]
IQF	Individual Quick Frozen
LNV	Ministerie van Landbouw, Natuur en Voedselkwaliteit (Ministry of Agriculture, Nature and Food Quality)
LoI	Letter of Intent
MARD	Ministry of Agriculture and Rural Development of the Socialist Republic of Vietnam
MRL	Maximum Residue Level
NFC	Not From Concentrate
PHLs	Post-Harvest Losses[8]
PC-1	Potato Company 1
PC-2	Potato Company 2
ROI	Return on Investment
SDGs	Sustainable Development Goals[9]
SP-1	Service Provider of PC-1
ULO	Ultra Low Oxygen
UNFSS	United Nations Food Systems Summit
WFBR	Wageningen Food and Biobased Research[10]
WUR	Wageningen University and Research

[1] Food Loss is the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retail, food service providers and consumers [2]

[2] A combination of Food Loss and Food Waste, thus covering the whole supply chain from harvest to consumption.

[3] Food Waste is the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food services and consumers [2]

[4] G0 seed potatoes are tuber seeds in the future. Also referred to us minitubers. This is the first generation of seed potatoes grown in tissue culture in the laboratory ([3], p. 7-8)

[5] These are potatoes which are harvested from G0 minitubers in the field ([3], p. 7-8)

[6] This is the next generation of G1 seed potato ([3], p. 7-8)

[7] This is the next generation of G2 ([3], p 7-8)

[8] Post-Harvest Losses are losses in the food supply chain after harvest until retail and (public and home) consumption, and hence is the same as Food Loss [2]

[9] 17 interlinked global goals designed by the United Nations to achieve a better and more sustainable future for all.

[10] A contract research institute and part of Wageningen University and Research

1 Summary

Each year possibly as much as 40% of the food produced is being lost or wasted somewhere between farm and fork. Also, in Vietnam there are significant food losses, and until now little effort has been made to reduce those losses. In this project the goal was to reduce food loss in selected Vietnamese food supply chains by combined efforts of Vietnamese stakeholders and Dutch companies and supported by Dutch knowledge on FLW monitoring and FLW reducing interventions. This study has not only provided insights into the amount of losses and where they arise, but also how Vietnamese and Dutch companies try to find each other when doing business, and which issues play a role in this.

2 Introduction

Food Loss and Waste globally

Food Loss and Waste (FLW) is a global problem. According to the most recent global studies worldwide, each year possibly as much as 40% of the food produced is being lost or wasted somewhere between farm and fork. This food which is produced but ultimately not eaten (i.e. lost or wasted) negativly impacts our food systems and our natural resources. It consumes 1/4th of the freshwater usage by agriculture, is grown on a farmland area greater than the size of China, contributes to the degradation of natural ecosystems and loss of biodiversity, and emits around 8-10% of our global greenhouse gasses [4].

Food production in Vietnam: FLW and environmental constraints

Vietnam's Post-Harvest losses (PHLs) are very high. A study from CEL Consulting in 2018 displayed that PHLs are in average 25%. These Food Losses (FLs) represent a value of US$ 3,9 billion and 2% of Vietnams' total GDP. An equivalent area of ~ 29,700km², 25% of the total Vietnamese agriculture land, is used for production of food that is not eaten. In terms of volume, losses are the highest in the fruit and vegetable chains (approximately 32% losses). However, losses are also considerable in the meat sector (14%) and in the fishery sector (12%).[11]
Next to the high PHLs, food production in Vietnam is facing environmental constraints. The World Bank Group recommended in a recent diagnostic study that future food production in Vietnam should focus on producing high value food with reduced environmental impact. FL reduction was identified as pivotal transition pathway in this regard [5].

SDG 12.3 and the Dutch and Vietnamese response to the global call for action

The Sustainable Development Goal (SDG) Target 12.3 calls to 'halve per capita global food waste at the retail and consumer levels and reduce FLs along production and supply chains, including post-harvest losses'. This goal should be achieved by 2030, in just over eight years from now. However, the world is far from being on track to achieve this target [6]. Although the Netherlands is a relatively small country, especially in comparison to Vietnam, it has a couple of Champions 12.3 who are dedicated to mobilizing action, and accelerating progress towards achieving SDG Target 12.3 by 2030. On behalf of Vietnam, Mr. Nguyen Xuan Cuong, the Minister of Agriculture and Rural Development, is also part of the world's leading Champions 12.3 in this field.[12]
As of 2009 FLW reduction is on the agenda of the Dutch ministry. From 2014 onwards the Netherlands has a Strategic Partnership Arrangement with Vietnam for cooperation in the field of sustainable agriculture and food security. This cooperation aims to strengthen trade between the two countries. During a visit of the Vietnamese Minister of Agriculture to the Netherlands in late 2019, a Letter of Intent (LoI) was signed with the Netherlands Ministry of Agriculture, Nature and Food Quality (LNV). Limiting FLs in Vietnam and the efforts of Dutch companies in this regard are important components of this agreement. Dutch know-how and technology are expected to play an important role here.
Within the framework of the LoI, this project was initiated. Wageningen Food and Biobased Research (WFBR) in the Netherlands, part of Wageningen University and Research (WUR), together with AgroInfo in Vietnam are working on a roadmap for Vietnam in order to reduce PHLs in selected Vietnamese food supply chains.

Project Objective

The objective of the project is to reduce FLs in selected Vietnamese food supply chains by combined efforts of Vietnamese stakeholders and Dutch companies and supported by Dutch knowledge on FLW monitoring and FLW reducing interventions.

Reduction of PHLs can increase existing business opportunities and create new ones. When quality of products can be maintained, sales value and profit can increase. Whereas when products go to landfill or animal feed the production and transaction costs lead to economic losses. Therefore FL reduction can

[11] https://www.cel-consulting.com/post/2018/08/10/Food-Losses-in-Vietnam-the-shocking-reality, viewed 11-4-2022
[12] https://champions123.org/the-champions, viewed 1-7-2022

contribute to more economically sustainable food systems. Next to that, saving food from being wasted leads to many environmental benefits and thereby also reduces the ecological footprint.

Project Phases

The project consisted of two separate phases. Phase 1 displayed the general picture of food supply chains in a given region. The most promising crops and geographic areas were selected. Besides, the best interventions and ways forward reducing FLs in the selected crop production regions were identified. Phase 2 zooms in on selected supply chains. It looks into options for PHLs reduction in the selected supply chains of selected chain actors in Vietnam by making use of Dutch technology and knowledge. Next to this, Phase 2 also explored opportunities for impact-oriented collaboration between Dutch and Vietnamese companies.

Project stakeholders

This project was commissioned by LNV on request of the Embassy of the Kingdom of the Netherlands (EKN) in Vietnam and AgroTrade, part of the Ministry of Agriculture and Rural Development (MARD) in Vietnam. WFBR and AgroInfo together represented the project team. The project team established direct linkages with selected Dutch- and Vietnamese organisations, such as fruit importing and exporting companies, big agro-cooperation's and associations, cold chain providers, providers of propagating material, processors, logistic companies, consultants and others.

3 Retrospect Phase 1

For Phase 1 the commissioning and requesting party, EKN and AgroTrade, aimed for selecting one domestic crop and one export crop. At least one of these two crops should be cultivated in the Mekong Delta. The project execution team elaborated various impact indicators[13] in order to derive the most promising crops for PHLs reduction in the context of this project,. Based on the impact indicators, a multicriteria evaluation process was executed by EKN and AgroTrade. Dragon fruit from the Mekong Delta (Long An Province) and longan from the Red River Delta (Hung Yen Province) obtained the highest marks and therefore were selected for Phase 1.

FL hotspots along the entire supply chain from the producer to the processor were identified. Data was collected via interviews, field trips, and direct measurements of FLW[14]. Based on the data collection per supply chain and crop a comprehensive FLW analysis was made. This included among others flow charting, a description of the supply chain characteristics per chain actor, an overview of losses per chain actor, a SWOT analysis, and a cause analysis of losses. The analysis took along FLs as well as economic losses. The latter one occurs when products fail to reach the targeted market and end up at less preferred destinations, leading to a lower or no sales price e.g. due to selling to juicer, consumption at home or donation to charity. Based on the analysis per crop a longlist with about 90 potential interventions for FL reduction, contributing to Dutch-Vietnamese collaboration and taking place in the postharvest chain, was established. According to the estimated potential and impact of the interventions this longlist was reduced to a set of 6-10 most promising interventions per crop. Regarding the feasibility we looked into the market requirements (for export to Europe, China, Japan/Korea, and the USA), the investment space for FL reduction and the effect on greenhouse gas emissions reduction. Thereafter, a longlist was established with about 80 actors who could potentially reduce FLs, because they are a chain actor or offer technology or services reducing FL. In order to come to a short list of those 80 actors the project team held direct interviews with selected parties like chain actors, importers, cold chain providers, a logistic provider, a bank, and consultants. Based on this assessment the project team identified eight Dutch- and fifteen Vietnamese organisations with potential interest in the business opportunities related to this project, especially in relation to the dragon fruit value chain.

For longan it was found that the production circumstances do not yet qualify for export to EU markets and that the investment space is limited. In the short- and medium term this combination narrows the potential for the establishment of business partnerships between Vietnamese and Dutch private sector companies. However, for the interested Vietnamese companies still plenty of interventions were identified, such as technical training on production and postharvest handling, establishing standards and protocols and improving of drying facilities at the processor. After evaluation of Phase 1, longan therefore was replaced with another crop (potato).

For dragon fruit a combination of parallel interventions on different chain stages was suggested to reduce FLs. Interventions included e.g. improvement of growing techniques and postharvest handling to increase the quality of the produce, installment of seamless cold chain and climatic control to extend the shelf life and prolonging the sales window, establishment of good practice protocols and standards, doing research on the dragon fruit physiology, and shift from air- to sea freight after shelf life is prolonged in order to supply high end markets. Based on our dragon fruit measurements carried out in January 2021, it was calculated that an average dragon fruit grower loses about €2,900 in value per year. That means that if 25 farmers reduce their losses by 70%, a realistic percentage, they could together buy a cold storage with an Return On Investment (ROI) of four years. Instalment of a cold chain, combined with a set of good practices, could lead to an extension of the shelf life and would open up the potential for a shift from air- to sea freight. Bigger volumes would become available at a lower price and losses would be reduced. The project team calculated that due to a shift from air- to sea freight the price per kg imported dragon fruit could diminish from currently ~ €4.50/kg to ~ €2.50/kg and Greenhouse Gas Emissions would be reduced from 26.49 kg CO_2-EQ per kg sold on EU-market to 16.09 CO_2-EQ.

That again would stimulate the interest of fruit importers in the Netherlands to develop the dragon fruit market from a niche market supplying to speciality outlets, to a more mainstream market supplying into the retail channels in Europe.

[13] Products were selected by a multicriteria evaluation process on several indicators like e.g. size of the production area, product trend increase/decrease of production, export, import, processing facilities available.

[14] Direct measurements were only used in the dragon fruit supply chain.

Based on the work in Phase 1 eleven conclusions were drawn up for dragon fruit and longan:

1. There was little knowledge on FLW in Vietnam in the selected chains. The research provided new insights in this field and showed where to focus on.
2. Although the supply chains of dragon fruit and longan showed many differences and had different target markets, they also had some things in common:
    a. For both crops FL hotspots are a) pre-harvest and b) sorting & grading.
    b. To reduce losses both supply chains could benefit a lot from: a) improved growing techniques, b) improved postharvest handling, c) uninterrupted cold chains and climate control, and d) economies of scale for transport, labour and knowledge.
    c. Both supply chains need more than only technical solutions to successfully reduce losses. One could think about long term commitment and agreements through the supply chains, access to finance, access to market information and so on.
3. FL hotspots and interventions to prevent them are not necessarily located at the same stage in the value chain: e.g., high loss rates during grading and sorting are typically the result of poor initial quality and/or improper handling earlier in the supply chain. Therefore, we need to understand the root causes of the losses to identify the best intervention options.
4. Each crop/product requires an integrated and customized approach, taking into account 'hardware-, software-, and orgware- solutions'[15]. An option such as vertical integration could ensure the exporter to receive reliable quality and quantity of fruits.
5. In dragon fruits there are good opportunities to reduce FLs in a profitable way by combined efforts of Vietnamese stakeholders and Dutch companies. For the reduction of losses in longan, local solutions are suggested.
6. To fully develop the business opportunities for Dutch companies a multi-annual strategic plan is needed which should include among other business case development, a communication plan, concrete scaling projects.

For dragon fruit the following specific conclusions were found:

7. There are interesting business cases for supply chain actors by investing in targeted loss-reducing measures. For instance, if 25 farmers reduce their losses by 70% they can invest together in one cold storage with a payback time of only 4 years.
8. FL reduction and quality improvements can allow for export by sea instead of by air to Europe. Also sea transport to other high-end markets in the region are within reach.
9. To allow successful export by sea reliable quality and quantity of dragon fruit is needed. Therefore, vertical integration of the exporters is suggested.
10. Compliance to good practice standards is almost mandatory for supply chain actors. Investing into compliance for export to high end markets means extra effort compared to supplying low standard markets like China. Moreover, China is increasing its own production area. It seems likely for the (near) future that their import requirements will converge to similar ones upheld by high-end markets.
11. Export development requires two important steps: vertical integration to reach high-end markets like Japan, Korea and Australia (lead time relatively small) and optimal cold chain management to prolong the shelf life which will allow access to far away markets by boat, like EU.

The final results of Phase 1 were presented to the participating stakeholders. The report of Phase 1 is published and available at https://doi.org/10.18174/548408 [7].

[15] Hardware: material equipment like for instance infrastructure, logistics, laboratories, or traceability systems; Software: knowledge, education, and research including training, developments of manuals and protocols; Orgware: organization of the institutions and chain actors like for instance the establishment of new rules or new collaborations, and the orientation towards new markets.

4 Approach Phase 2

Phase 2 was built on the results and learnings from Phase 1. It consisted of two main work packages, each of them addressed one selected food production chain.

The data collection for both work packages took place via a mixed methodology of stakeholder discussions, in-depth interviews, matchmaking meetings and literature research. The priority was especially on the in-depth, one-on-one interviews with the stakeholders in Vietnam and the Netherlands. The project team thoroughly assessed and selected the companies on their interest and needs before it organized matchmaking meetings. See for more information Figure 1 below.

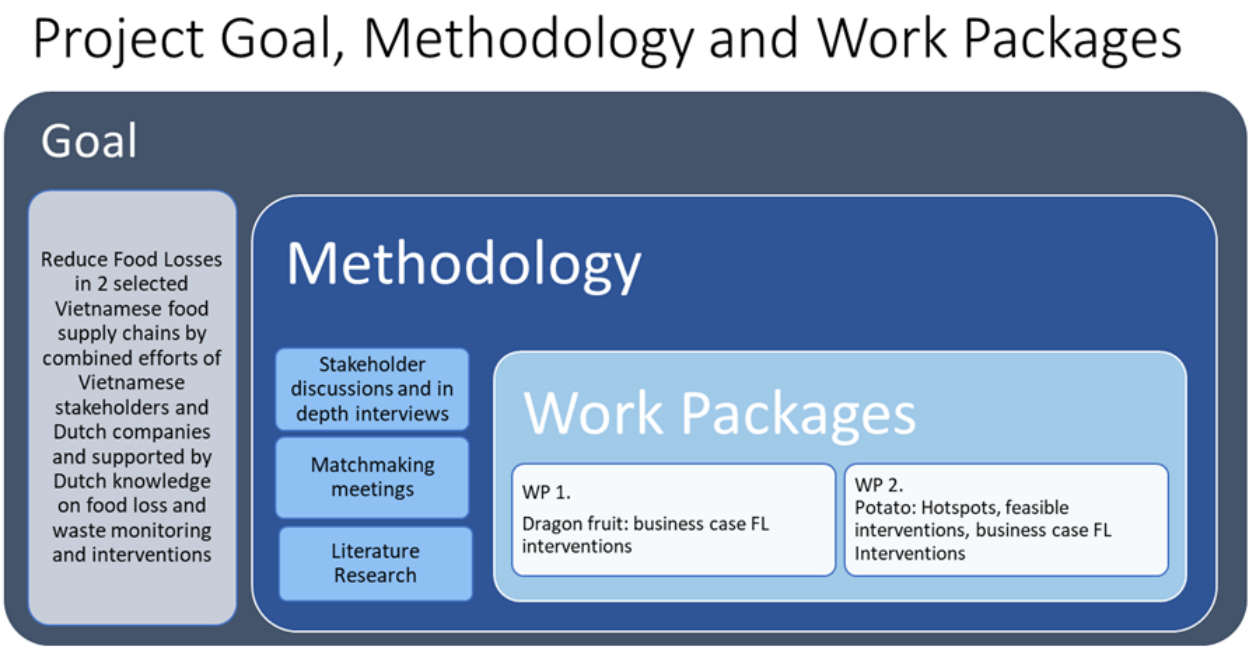

Figure 1: Project Goal, Methodology, and Work Packages

Work package 1 focused on dragon fruit. In order to reduce FLW, concrete business cases need to be identified, including investment space for interventions, for the selected companies and their dragon fruit supply chains. For that purpose, WFBR developed the EFFICIENT protocol[16] to identify FLW hotspots quickly, including FLW causes and possible interventions[8]. The EFFICIENT protocol was applied in order to make a detailed analysis on the feasibility of vertical integration, the potential to halve current retail price for dragon fruit by reducing losses, extending the shelf-life, integrating vertically, and shift the transportation modality from air- to sea freight.
The following activities took place in Work Package 1:

1) Selection and quick assessment of the most promising Vietnamese parties for the redesign of the supply chain (criteria e.g. interest in this project, scale, investment space, maturity of the organization) via one-on-one interviews.
2) Apply elements of the EFFICIENT protocol to analyse the supply chain at hand, determine the investment space, causes of FLW and possible interventions.
3) In depth interviews with Dutch parties to discuss and specify in detail the intervention characteristics.
4) Matchmaking between Vietnamese and Dutch companies.

[16] See Annex 1 for a short description of the tool. More can be found in reference [8].

For Work Package 2 an intermediate step was needed. Due to reasons mentioned in Chapter 2, it was decided that longan should get replaced with a more promising food product for this project. This should be a product with more investment space and therefore better potential than longan to involve Dutch private sector companies and establish partnerships between Vietnamese and Dutch companies. Potato for the processing industry, avocado, mango, shrimps, and pangasius were shortlisted as potentially interesting focus products. For those five products a quick scan was made based on a literature review and stakeholder interviews in both countries. The selection criteria were: significant PHLs, interest from Vietnamese and Dutch companies, relevant product for Dutch knowledge and expertise, high value product, significant production in Vietnam, detailed knowledge available of the food supply in Vietnam, good production window, right varieties according to market preference, and ideally a relation to the Mekong Delta. Except for the last criteria, potato received the highest marks for all criteria. Potato was therefore selected by EKN and AgroTrade as the focus product for Work Package 2.

Work Package 2 focused on the identification of the hotspots and feasible interventions in the potato supply chain from seed till processor. Thereafter, activity 1 to 4, as explained under Work Package 1, were carried out.

5 Dragon Fruit business case

Vietnam has more than 64,000 ha of dragon fruit. Binh Thuan (33,000 ha), Long An (nearly 12,000 ha), and Tien Giang (9,600 ha) are the main dragon fruit production areas. The Vietnamese dragon fruit agricultural sector relies heavily on the Chinese market. Dragon fruit sales to China accounts for more than 90% of the total export volume[17]. This leads to high dependencies and especially becomes critical when borders are closed or demand decreases. Access to other markets, like the market in the Netherlands, could lead to less dependence by diversifying the sales outlets. However, as explained in previous chapters, that would need to go along with interventions which would increase the quality, prolong the shelf life, and thereby reduce the losses. Dutch knowledge and technology like cold- and controlled atmosphere (CA) storages could provide support in this regard.

The sections are numbered according to the steps described in the previous chapter.

5.1 Vietnamese companies (selection and background)

Below we describe the pre-selected companies in Vietnam. Information is based on the interviews and public information. It does not necessarily represent the views of the authors. Given the confidentiality of the information all company names are anonymised. In Vietnam 12 dragon fruit companies were selected for assessing cooperation opportunities and interested in collaboration with Dutch companies to reduce FLs in the dragon fruit value chain. Out of the quick scan assessment via interviews, three companies were shortlisted for having the most potential. All three are leading Vietnamese fruit companies, growing and exporting dragon fruit, and expressed interest in this project. Below we give an overview of their characteristics.

Dragon Fruit Company 1 (DFC-1)

Dragon Fruit Company Number One (DFC-1) was established many years ago. In its early years it focused on dragon fruit production. However, thereafter it quickly established into a leading enterprise, growing and exporting dragon fruits from Vietnam at scale. Today, DFC-1 possess a dragon fruit farm with an extension of several hundred hectares and provides markets for huge amount of external dragon fruit producers annually, including special varieties. Its dragon fruit supply is year-round. The farm has a modern on-site warehouse, holds a GlobalGAP-certificate, and meets as well export standards for Europe, the United States, Japan, Korea, and other high end countries. Sales in those markets are constantly expanding. Export sales revenue reach millions of US$ annually and it represents high percentage of Vietnamese dragon fruits sales in the European market.

Dragon Fruit Company 2 (DFC-2)

Dragon Fruit Company Number Two (DFC-2) was established many years ago. It is specialized in fresh dragon fruit. Apart from dragon fruits DFC-2 also sales other tropical fruit like mango, papaya, longan, rambutan, bamboo shoots, durian, and banana and commercializes processed fruit. It is a leading Vietnamese buyer and exporter of dragon fruit of different varieties. Exports take place to markets which require vapour heat treatment technology (VPH) like Korea, Japan, Taiwan, Australia as well as to those markets who do not require it.
The company works closely with the farmers and supports them in producing high-quality fruits. Farmers are certified for VietGap or/and GlobalGap standards. The company invests in infrastructure improvements for packaging and cold storage.
Dragon Fruit Company 3 (DFC-3)

[17] https://baotintuc.vn/kinh-te/tim-huong-san-xuat-va-tieu-thu-thanh-long-ben-vung-20220221144301107.htm, viewed 11-4-2022

Dragon Fruit Company Number Three (DFC-3) was founded many years ago. It is an innovative and vertically integrated fruit and vegetable grower, processor and exporter. Dragon fruit is the core product of DFC-3. It is specialized in juice/ Not From Concentrate (NFC), puree, concentrate, and IQF (Individual Quick Frozen). The focus is on processing. The fresh segment, compared to the processed one, is a relatively insignificant segment for DFC-3. It is a major buyer of fresh and processed fruit from various regions in Vietnam. Its own value chain from the raw material supply to the harvesting, processing & manufacturing, exporting and distribution is fully controlled and the processing is equipped with advanced technology.
The Company's processed products are distributed all over the world, especially in Europe, the United States, Oceania, the Middle East, Japan and South Korea.

5.2 Efficient protocol on dragon fruit loss and waste

In the next paragraphs the relevant steps in the EFFICIENT protocol (as presented in Annex 1) are applied for the dragon fruit case.

Scope and flow

Promising Vietnamese partners with whom a business case could potentially be achieved were listed, contacted and interviewed. At the end of this process one of the preselected processing/exporting companies was selected that showed interest in FLW reduction by investing in technology and knowledge. The business case was the dragon fruit supply chain from farmers in the Mekong Delta that supply via traders and wholesalers to this company until arrival in the Netherlands at the importer's facility.

During the project AgroInfo (part of the project execution team) visited the Mekong Delta and carried out several interviews per actor type. The result of flow analysis of the dragon fruit supply chain at hand is shown in Figure 2.

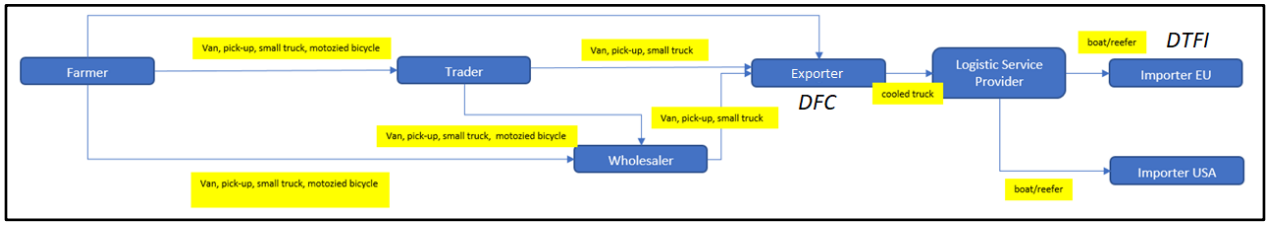

Figure 2: the dragon fruit supply chain of (one of three of) the Vietnamese companies considered in this project

Note that the exporter has some farmers that supply to the company only.

Focus and causes

In the focus phase the hotspots of FLW were identified based on a quantitative analysis. Expert interviews elucidate weights and prices throughout the supply chain. The data collection showed ranges of losses and prices. To calculate the potential annual benefit there are a two decisions to make. First, one can take the average of the received data or the lower bound to stay on the safe side. Second, the value loss can be calculated in cost and sales price. If the production costs of 1 kg of dragon fruit is 8,000 VND[18], and the selling price is 12,000 VND, then the value loss per kg can be either 8,000 or 12,000. In the authors analysis below (Table 1) the average value is taken for FLW and the sales price is used. The opportunity costs can be used to calculate the investment space.

[18] Note that 1000 VND = 0,044 USD, https://www.xe.com/currencytables/?from=VND&date=2021-09-07#table-section, viewed 7-9-2021

Table 1: FLW in weight and value for the dragon fruit supply chain at hand in one year

Stakeholders	Name actor	Activities	Destination	FLW volume		Opportunity costs
				ton	%	Million VND/year
Stakeholder 1	Farmers (not owned)	Harvesting	Throw away/animal feed	1,300		22,750
		Sorting	Animal feed	1,050		18,375
			Processor	650		8,775
Stakeholder 2	Farmers (owned)	Harvesting	Not harvested	130		1,040
TOTAL	**Farm level (not owned)**					**49,900**
Stakeholder 3	Trader/ Wholesalers	Transport (short distance)	No significant losses	0		0
Stakeholder 4	Exporter	Sorting	Sold at domestic market	3,411		30,699
		Packaging	Sold at domestic market/processor	341		3,069
		Storage	Processor	114		2,052
		Transport to EU	Fermentation or composting in NL	600		13,200
TOTAL	**Exporter (excl. processor)**					**46,968**

The total value loss for the exporter equals 46,968M VND, which equals 2,067k USD. Looking at the value loss at farm level the value is 49,900M VND ≈ 2,196k USD.

Table 1 shows that hotspots are mainly at:

- Farm level (not owned): harvesting and sorting.
- Exporter: sorting and transport to EU.

However, the causes might be found at a different stakeholder than where the FLW occurs. The following causes resulted from stakeholder interviews:

- In high season lower quality and more losses due to pests and diseases and many rainy days.
- Exporter has to buy whole harvest (including lower quality) otherwise farmer sells to somebody else.
- Breaking ears of dragon fruit due to transport, packaging material and over-packing.
- Shelf life is too short given the current transport conditions and the lead time of 35 days by boat to the EU.

Figure 3: dragon fruit transport from farmer to market[19]

Interventions

The exporting company has no control over the majority of the supplying farmers. This leads to a variety of farmer practices and non-uniform produce, which is an issue since uniform products is a typical market requirement from EU clients. To decrease the losses at farm level and during sorting at the exporter more vertical integration is recommended to set up standardized good farmer practices and apply stackable transport packaging (decreasing weight pressure, see Figure 3).

[19] https://vietnamnews.vn/sunday/features/297618/dragon-fruit-brings-farmers-sweet-success.html, viewed 31-5-2022

Another advice is changing the transport conditions from temperature controlled to CA This was suggested by the Vietnamese partner, whereas WFBR suggests a proof of principle first. Travel distance between farmers and exporter is small, hence (if time between harvest and transport is short as well) main focus for controlled climatic conditions is at exporter and including transport to the EU importer. The Vietnamese companies requested to look into CA storage and transport, a technology that is not available in Vietnam at the moment.

5.3 Dutch companies (background)

The major step to reduce FLW is training at farm level. However, without contract farming or vertical integration this is a risky investment, since farmers are not necessarily committed. Therefore, the focus is on exporting high quality dragon fruit to the EU. This not only requires a technical solution to extend shelf life but also a market, that will determine the requirements for the supply chain. On the Dutch side, one exotic fruit importer and one technology providing company were selected as companies with whom potentially interesting new business relations going along with loss reductions in dragon fruits in Vietnam can get established. In the following we provide a brief description of those two companies.

Dutch Tropical Fruit Importer (DTFI)

The selected Dutch Tropical Fruit Importer (DTFI) is a well-established and leading fruit and vegetable importer in the Netherlands. The company brings fruits and vegetables from around the world to the homes of consumers all over Europe. The majority of the produce is delivered into to the retail channel, a minor part to the wholesale market, and a relatively small percentage to the processing industry. The company holds many years of experience in the sector and provides support to optimize the product range. It has a close link with their suppliers and is investing into long-term relationships with them.
The DTFI is holding a variety of sustainability- and food safety certificates, and is working according to high standards. Creating a positive influence on People and Planet is their aim. Not only on its own People and the environment in the Netherlands, but also of those of the supplying farmers. Together with their suppliers the company takes steps towards a better world. The DTFI feels responsible for the products they trade. FLW reduction is one of its focus topics. The company constantly looks into opportunities to minimise residual flows and find new destinations to combat FLW.

Dutch Technology Supplier 1 (DTS-1)

The Dutch Technology Supplier Number One (DTS-1) is a global leading player in its field. It is specialist in storing and processing of fresh and frozen produce. It designs, manufactures and installs cold storages and air-conditioned process areas from harvest all the way to the consumer. It can provide cooling/freezing systems at farms and nurseries till the wholesalers. The company works around the world and provides solutions for various market segments from agriculture (vegetables, fruits and potatoes) to horticulture (flower and flower bulbs) and food processing (meat, fish, vegetables and fruits). It has vast experience in all kinds of refrigerant systems: central or decentral; direct cooling or indirect cooling; working with natural refrigerants like ammonia, propane and/or CO_2 as well as environmentally friendly HFC refrigerants. Next to this it holds knowledge about fresh produce and is working with its own software engineers. The DTS-1 is committed to provide technologic solutions with low operational cost, and 24/7 reliable service and maintenance. It has offices with representatives in various countries in the world, however not yet in Vietnam.

5.4 Assessment and Matchmaking Vietnamese and Dutch partners and results

Assessment and Matchmaking

The Project Team assessed the five companies in individual meetings on the potential to create win-win relations reducing FLW in Vietnam. Based on the assessment it was decided that for DFC-3, due to its strong focus on processing and exporting outside Europe, the Dutch companies would not have much to offer. Therefore only with the DFC-1 and DFC-2 matchmaking meetings were organized with the Dutch companies. One matchmaking meeting took place with DFC-1 and DTFI and DTS-1 and a separate meeting was set up with DFC-2 and DTFI and DTS-1. Apart from the fact that for each Vietnamese company one matchmaking meeting with the Dutch companies was set up, the further setting of the two meetings was similar. The meetings started with an introduction by the project team introducing the project, the objective of the meeting, and the results and ideas so far. The companies introduced themselves, their products, activities and their requirements. Thereafter the project team not only facilitated exchange and discussions in the matchmaking meeting itself but also facilitated follow up after the meetings. Translation was provided by the project team from English into Vietnamese and vice-versa. The level of English was not in all case sufficient for direct discussion between the Vietnamese and Dutch companies.
In both meetings, the DTS-1 proposed to design an Ultra-Low Oxygen (ULO) storage to extend the shelf life. As up till now no research or proof of principle has been executed on how dragon fruits behave under CA conditions and how much this technology can potentially extend the dragon fruit shelf life, the DTS-1 offered to set up a small initial pilot test outside Vietnam to get a first indication on the effect of CA on dragon fruits. Regarding the instalment of ULO storage the DFC-1 indicated that they have already a warehouse which is sufficiently equipped with cold storage facilities. Current facilities are meeting their needs, and therefore they do not have a demand for new facilities. Despite that, they were still interested in testing such a new technology. Also DFC-2 indicated that it has already cold storage facilities in their different warehouses. However, they showed much interest in this new technology of the DTS-1. Their current facilities and technology are older and they are planning to install a new cold storage system. With regard to the offered pilot test with dragon fruit also DFC-2 indicated that they are interested in providing dragon fruit samples to conduct some first CA tests.
The DTFI explained its requirements and how they establish relationships with new suppliers. With regard to the fundamental requirements all their supplied products have to comply with the general food safety regulations and standards and thus have to be certified for GlobalGap, BRC, and comply to the maximum in the EU allowed Residue Levels (MRL) on pesticides. In addition, they also have to be certified according to international recognised social sustainability standards. The Dutch importer explained that they continuously are working on making their assortment more sustainable. Moving more and more away from airfreight is one of the targets in this relation. Before they go into the real programming with their suppliers, they normally start with a test shipment. With regard to dragon fruit the minimum shelf life they need is 7 days. They explained that the dragon fruit volume sold in Europe is still very limited. Dragon fruits are not yet much known. Smaller volumes go to speciality markets but dragon fruit is not yet distributed at scale into the normal retail channels. In order to penetrate with dragon fruit into the European retail channels in a similar way as several years ago with mango's, a condition would be that the price of dragon fruit drops to around EUR 2.50/kg. That can be achieved by moving from air- to sea freight. Also the Dutch tropical fruit importer indicated that they are interested in tests for a better understanding of the dragon fruit's post-harvest physiology and opportunities for shelf life extension. Next to this, they are interested in test shipments via sea freight. But again, a condition for test shipments would be that the price per kg lies around EUR 2.50.
Both Vietnamese companies expressed interest in setting up business relationships with the DTFI. Prior to the Covid-19 pandemic, the companies even occasionally shipped some part of their exported dragon fruit by sea from Vietnam to Europe. But since the outbreak of Covid-19 both companies perceive transportation by boat to Europe as being very risky. The shipping time extended from 22-25 days pre Covid to 30-40 days at this moment. Whereas the maximum dragon fruit shelf life they can achieve at this stage lays around 20-30 days. That means that boat transportation for dragon fruit is currently out of scope. New interesting business opportunities will open up when shipment times go back to the situation pre Covid and/or the dragon fruit shelf life can be prolonged reliably to at least 40-50 days. Under these circumstances the Vietnamese dragon

fruit companies showed much interest in starting test shipments, preferably first outside the rainy season, thus from Oct/Nov-April, to avoid quality risks.
After the matchmaking meetings the DTS-1 developed a cold storage design for the Vietnamese dragon fruit companies and made an offer for a CA cold storage in Vietnam. Yet, the investment decision of DFS-2 on Dutch technology with CA cold storage is not taken. The project team bilaterally followed up with the companies to get their opinion on the matchmaking meeting and guiding them towards bilateral business contacts with each other so that they can follow up on test shipments and/or pilots.

Conclusions from the meetings and discussion

In general, the business situation for Vietnamese dragon fruit companies has become difficult since the outbreak of Covid-19. China, Vietnam's largest export market for dragon fruits, still maintains a zero Covid policy in order to prevent the entry of the epidemic. As a result of this, China has repeatedly tightened the management of import and export activities at border gates with Vietnam. These developments made exports from Vietnam to China risky, especially for perishables with a limited shelf life.[20] Next to this, production costs as well as exporting and logistics costs - both for air freight and sea freight - have gone up. Considering this situation, the dragon fruit price cannot easily drop to EUR 2.50/kg in the present circumstances. Despite these unfavourable external global developments outside the circle of influence of any individual company, the business strategy of the two dragon fruit companies is to supply high-quality products to premium markets like the Netherlands. Both companies made long-term investments in this regard to meet the market requirements like GlobalGap certifications and compliance to other standards. Cooperation between Vietnamese dragon fruit companies and the Dutch companies have to face these challenges and find intermediate solutions. The full opportunities for cooperation are likely to reopen when the logistics problems are solved. The meantime could very well be used to find ways to extend the dragon fruit shelf life. Yet not much is known about the dragon fruit physiology and the behaviour of the fruit under for instance CA conditions. Proof of principles and shelf life tests with various promising settings and dragon fruit varieties should be set up. Results would shed light in getting to know the physiology of dragon fruits and the most appropriate shelf life extending pre- and postharvest a settings.

Regarding the cold-storage installation, the two Vietnamese companies expressed much interest in some initial shelf life pilot tests and even willingness to pay for the tests. However, the follow up is pending for unknown reasons. As tests are outside the scope of the running project activities the project team had to leave it here. Also, although the result of such an initial test under CA conditions is interesting, such an initial test is far from being sufficient to understand the most promising range of shelf life prolonging interventions for dragon fruit and to provide data driven evidence on the impact of the interventions. It might be more effective and interesting to have a fund allocation to test various settings and make the results publicly available to boost the dragon fruit supply to attractive, more far away markets with higher quality requirements.

The fact that the Dutch and Vietnamese companies could not exchange sufficiently directly in English, means that doing business with each other might require an intermediate person for translation. English is the main business language for internationally oriented companies in the Netherlands. Especially in fast moving consumer goods like fruits, absence of direct communication lines might cause inconvenience leading to delays and/or misunderstandings.

[20] https://trungtamwto.vn/file/21518/6-nong-san-gap-kho-tq.pdf, viewed 11-4-2022

6 Potato business case

Vietnam has a total potato production area of 18,804 hectares[21]. For the period from 2018-2022 Vietnam targeted that the potato area should reach and stabilize at 30,000 hectares. Whereas in 2023 it should increase to 35,000-40,000 hectares[22]. The traditional potato production areas are the Red River Delta, the Northern mountainous region in winter and Central Highland (Da Lat/Lam Dong) where the production is year-round. The Red River Delta and the Northern mountainous region have a temperate climate in wintertime with temperatures ranging from 17-22°C and good structure soils like sandy soil, light loamy soil, alluvial soil and riverside alluvial soil that has the ability to retain moisture and heat and is rich in nutrients. While Central Highland has an altitude of 500 - 900m above sea level, with a daytime temperature of about 22-25 °C and 16-18 °C at night with loose basalt red soil which are very suitable for potato plants, the potatoes yield can be from 20- 40 tons/ha, which is 10-15% higher than in other areas. In recent years, new potato production areas were established in Central highland such as Dak Lak, Gia Lai and Dak Nong[23]. The total production of potatoes in Vietnam was 294,000 tons in 2020. The main production is for the domestic market and just a small amount is exported to neighbouring countries, including Laos (90% of the exported potatoes), Hong Kong (4,1%), Malaysia (2,9%) and Thailand (1,7%).
In the Vietnamese market, the potato snack industry is growing with an annual growth rate of double Digits. Before 2008 the supply of potatoes for snack factories depended mainly on imports from abroad. Growing potatoes on an industrial scale only developed in the recent years in Vietnam. Potatoes produced for the processing industry are targeting the industry in the local market. The demand of the processing plants for raw potatoes is estimated at more than 180,000 tons/year. The domestic production can meet about 30-40% of this demand[24]. The national production can supply potatoes from September to March/April (interviews 2021/2022).
More sophisticated storage solutions combined with a well-controlled supply chain often can solve the seasonality of a crop. In the Netherlands, for instance, potatoes' availability is continually being extended thanks to improved storage methods. In Vietnam, storage solutions have so far only been able to prolong the Vietnamese potato season for about two months. This relatively short storage time already leads to considerable losses. Therefore, from June till September Vietnam is mainly importing potatoes from outside Vietnam, both for consumption and processing[25] (interviews Vietnamese and Dutch companies 2021 and 2022). Import takes place from various countries e.g. China, India, US and Germany. This is costly, leads to high dependency, and it is doubtful how sustainable and competitive it can be in the long run. Alternatively, better seed potatoes for G1[26] potato seeds and improved multiplication of G2[27] potato seeds combined with the enhanced overall management of the supply chain and improved storage facilities could improve the quality of the potatoes, reduce the losses, and extend the supply window for potato chips produced in Vietnam. The assumption is, that ultimately, - with the right seeds, practices, technology and handling in place - even a year-round supply of potatoes out of Vietnam could be within the reach. Other tropical countries, e.g. India, have already built the proof of principle that the seasonality of the potatoes can be prolonged considerable (interviews Vietnamese and Dutch companies 2021 and 2022).

The project team pre-selected and assessed two key actors in the potato value chain in Vietnam and two key actors from the Netherlands. The selection criteria for the companies in Vietnam were: considerable size of the company, FLW problem which could potentially be solved by the technology and inputs provided by Dutch companies, interest in this project, and willingness to cooperate with the project team and share

[21] https://www.fao.org/faostat/en/#data/QCL, viewed 11-4-2022
[22] https://thanhnien.vn/viet-nam-dang-phai-nhap-tren-60-khoai-tay-de-che-bien-post772904.html, viewed 11-4-2022
[23] http://ast.apmb.gov.vn/Upload/Download/Baocaotongketdetai/49.%20Nguy%E1%BB%85n%20%C4%90%E1%BA%A1t%20Tho%E1%BA%A1i.pdf, viewed 11-4-2022
[24] https://baochinhphu.vn/phat-trien-san-xuat-khoai-tay-theo-xu-huong-tieu-dung-102241659.htm, viewed 11-4-2022
[25] https://toquoc.vn/tu-thang-6-9-hang-nam-viet-nam-thuong-nhap-khau-khoai-tay-tu-trung-quoc-99240289.htm, viewed 11-4-2022
[26] G1 are potatoes which are harvested from G0 minitubers in the field, Potato seeds classification (potato-seed.com), viewed 1-7-2022
[27] G2 is the next generation of G1 seed potato, Potato seeds classification (potato-seed.com), viewed 1-7-2022

information and data. For the Dutch parties the selection criteria were: ability to provide a FLW reducing solution for the identified hotspots and interest in the project and the selected geographic region.

6.1 Vietnamese companies (selection and background)

The project team pre-selected two leading Vietnamese potato companies and had specifically in depth discussion with a service provider of a leading Vietnamese potato company (=SP-1). Below we give an overview of the characteristics of those two companies.

Potato Company 1 (PC-1)

Potato Company 1 (PC-1) is a leading international company. It offers high-quality potato snacks to consumers and holds a significant market share in the potato snack segment in the Vietnamese market. It has a long history in Vietnam. Initially it imported potato snacks from outside Vietnam into the Vietnamese market. But in the meantime PC-1 has its own processing plants and production areas in Vietnam for years. Raw material is partly coming from own production, partly from dedicated farmers with whom they established long-term commitments, and partly imported. During the last years PC-1 continued to grow. That went along with the need for increased imports of raw material from outside Vietnam. PC-1's storage facilities are equipped with a cooling and ventilation systems.
PC-1 provides to farmers all kind of technical support, including inputs like seeds and fertilizers. For the seed production PC-1 is partnering with a leading research institute in Vietnam (SP-1). On behalf of PC-1 the Vietnamese research institute is in charge of research on seed potatoes, and multiplication and storage of seed potatoes. This service provider also has several storages for the storage of seed potatoes. It holds more than 20 years of experience in potato production.

Figure 4: seed potato production at SP-1 (source: SP-1)

Potato Company 2 (PC-2)

Potato Company 2 (PC-2) is a global player in the food sector and plays an important role as well in the snack segment. It is a pioneering company where it comes to growing potatoes on a commercial scale for processing in Vietnam. The company started its own agricultural project for growing potatoes many years ago. Over the past years, the company invested in its raw material supply. It provides to farmers technical support as well as improved inputs like seeds and fertilizers. The company has different dedicated supplying areas in Vietnam. In the past decennium, the company was able to increase the potato yields per hectare on average by more than three times from 8 tons/ha to 25 tons/ha. The company has an international research centre and within Vietnam it collaborates with local scientists.

PC-1 was shortlisted as promising company for the project. PC-1 introduced the project team to its service provider (SP-1) as central contact person for the project. SP-1 is in charge of research on seed potatoes, and

multiplication and storage of seed potatoes. But it also provides training to farmers on how to grow potatoes to get a good production (e.g. good practice, harvesting) and is inspecting the potatoes during the harvest to make sure that grown potatoes match the quality requirements of PC-1. Therefore, the focus of the project team was much on the upstream losses and indicatively on the more downstream losses taking place later on in the supply chain at the level of the processor.

The project team also contacted PC-2 and had several meetings with different representatives of the company to assess interest in the project and understand their challenges and possible interventions. The interviews showed that PC-2 has no potato supply out of Vietnam from May to September. In those months they need to import potatoes from other countries, often from overseas. Those imported volumes represent ~¼ of their annual potato supply. For two months, October to November, PC-2 stores potatoes from the local production. Although the storage time is still limited, PC-2 has to deal with a lot of losses. Storage for year-round supply is not yet the practice. Unfortunately, PC-2 decided not to cooperate in this project. This is especially a pity as the selected solutions offered by the Dutch companies would have matched quite well the encountered challenges. In the meetings with company PC-2 it became apparent that the company is mainly familiar with and interested in large-scale projects covering the whole national potato sector in a multiannual focus. As the project terms of references and the company's interest did not match, no further cooperation could be reached.

6.2 Efficient protocol on potato FLW

Scope and flow

The scope of this business case is limited, since one organization is coordinating the supply of 15,000 farmers, that partly supply their harvest to the potato processing company (crisps). This organization provides seed and training for the farmers. The distance from farm to factory ranges from 5 to 210 km, which is relatively close. The annual input for the processor is between 22,000 and 25,000 tons per year. From the farmers that are linked to the seed potato producer in the project, about 8,500 tons is supplied to PC-1. Several months per year there are no potatoes available in Vietnam and the processor imports from among others USA and Germany.

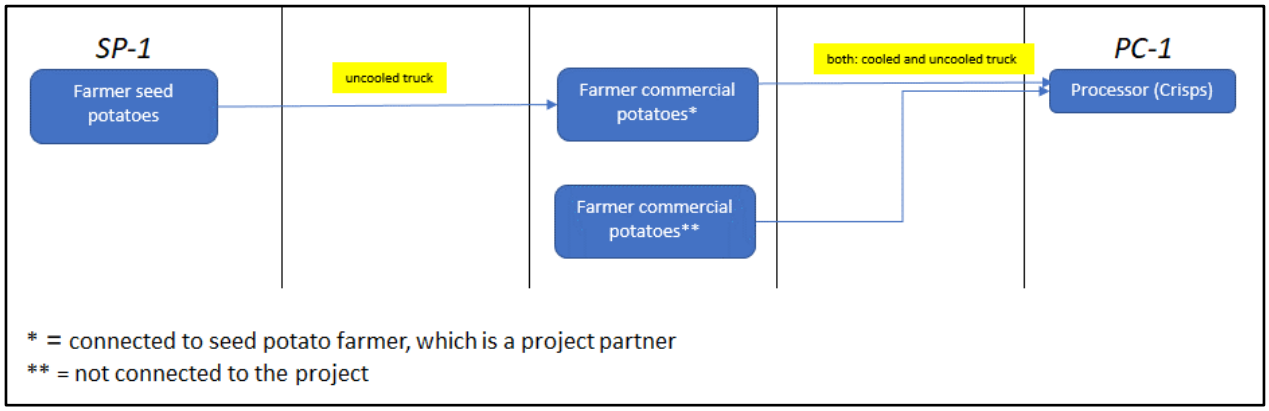

Figure 5: the potato supply chain of the Vietnamese companies considered in this project

Focus and causes

Based on information from the stakeholders there are several hotspots. Firstly, at the seed production level, where 1,000 tons of seed potatoes are grown annually, and 15% is lost during storage, due to sprouting and probably as well weight loss from drying, that again is caused by suboptimal airflow temperature (discussion with stakeholders). Farmers pay 20,000 VND/kg for the seed potatoes, hence the opportunity costs (value loss) equals 3,000 MVND (132 kUSD) per year. The conversion from seed potatoes to commercial potatoes is about 10, so 8,500 tons (10,000 minus 15%) of them are grown by the farmers connected to the seed potato producer PC-1. At farm level (G3 potato production for processing), 20-30% of the production is not suitable for crisp processing. This comes down to about 25% x 8,500 = 2,125 tons. The price paid by the

processor for commercial potatoes from the farmer is 7,700 VND/kg, leading to opportunity costs of 16,362 MVND (720 kUSD). At the processor where losses are at arrival (quality control) and during storage (8% losses), in total about 10%. They store for 3 to 4 months about 7,000 tons, and hence losses are about 700 tons (storage 560 and quality control 140). Transport costs are 400 VND/kg and hence the value per kg potato at the factory is about 8,100 VND, implying a value loss of 5,670 MVND or 249 kUSD per year. It is not clear if the losses at the factory are caused by the potato variety or the storage (technology or/and control). An additional remark was on the suitability of the potato varieties that are used, since the crisp quality is suboptimal.

Table 2: FLW in weight and value for part of the potato supply chain at hand in one year

Stakeholders	Name actor	Activities	Destination	FLW volume		Opportunity costs
				ton	%	Million VND/year
Stakeholder 1	Seed potato producer	Storage	unknown	150	15	3,000
Stakeholder 2	Farmers (connected to PC-1)	Sorting	animal feed	2,125	25	16,362
Stakeholder 3	Processor	Storage	unknown	560	8	4,536
		Quality control	unknown	140	2	1,134
		TOTAL		**700**	**10**	**5,670**

The cause for rejection at farm level is that farmers often do not follow the guidelines of good practices. Land on which seed generations one to three (G1-G3) are produced, must not have grown potatoes for a minimum of five years. Land on which subsequent generations are produced (i.e. G4 and G5) must not have grown potatoes for a minimum of three years [3]. But also diseases and rotting occurs. Hence the potato of G3 (potato generation 3) often does not meet the quality requirements of the crisps processor after harvesting.

Interventions

The impact of seed potato variety on the one hand and farm practice on the other hand is huge throughout the entire supply chain. But also the storage conditions at the seed potato producer can be improved by adding an evaporator that optimizes the air flow temperature for cooling. It is therefore recommended to discuss a pilot with support from a Dutch technology provider and/or a Dutch partner, that can provide seed potatoes for crisps production. An integral approach including farm practice management and storage at the processing factory is necessary to solve the loss issues. The opportunity costs are high: 132 kUSD at SP-1, 720 kUSD/year at farm level and 249 kUSD/year at the factory. Backward integration of the supply chain is already there, which reduces the investment risk significantly.

6.3 Dutch companies (background)

On the Dutch side, one input provider for potato seeds and a company offering technologic solutions for improved storage facilities were shortlisted. Quality seeds and appropriate storage solutions, combined with a set of good practices, can potentially lead to loss reduction in the potato value chain in Vietnam. Although the scope of the project was actually the post-harvest chain and not the pre-harvest chain, the project team decided to include a seed provider for FLW interventions. The reason for this was that the use of poor seed potatoes was one of the identified root causes for FLW later on in the postharvest chain and the Netherlands is a leader in the field of certified seed potatoes having a worldwide market share of more than 60%[28]. In the following we provide a brief description of both companies.

[28] https://www.seednl.nl/blog/potato-platform-for-transforming-potato-sectors, viewed 1-4-2022

Dutch Input Provider 1 (DIP-1)

The Dutch Input Provider 2 (DIP-1) holds about many years of experience in the field of potato breeding. It is a world leading breeder and research company developing new certified and high quality potato varieties, seed potatoes and potatoes grown for human consumption. It delivers strong and healthy potato varieties to destinations around the world. Direct operations take place in more than 80 countries, either directly or via branches. Recognition of breeders rights in its operating countries is a condition. DIP-1 has a close link with its breeders, growers and buyers and feels responsible for its employees. It works intensively on developing new, innovative potato varieties to meet the specific wishes of customers around the world. Breeding focuses on many characteristics, including yields, improve of nutrients and taste, storability and so on. The company developed many new unique potato varieties that match the needs and preferences in various countries. It has a strong commitment towards sustainability, and alligned its sustainability agenda towards the Sustainable Development Goals (SDGs). DIP-2 has some history in working in Vietnam, mainly via a representative.

Dutch Technology Provider 2 (DTP-2)

The Dutch Technology Provider 2 (DTP-2) has many years of experience. It provides storage solutions of high quality and was able to change with its storage solutions whole industries. It offers over 100 different types of machines and can provide complete storage solutions in an integrated 'one stop shop' approach from field to packaging combining e.g. storage solutions with the processing and loading and unloading lines. DTP-2 is a real specialist in providing comprehensive storage and processing solutions for potatoes, onions, and vegetable processing. It offers the full product range of line machinery for different parts of the produce handling process. It can for instance deliver loading and unloading machinery, grading solutions, but also equipment for cleaning, polishing, drying, cooling, inspection, handling, filling, palletizing, weighing and bagging. DTP-2 has a branch office in Asia. There it produces in its own facilities much of the equipment for cooling and processing. Having own production means that the company can guarantee high quality at a competitive price, fast delivery, and quick adjustment to latest developments in technology and design. Next to hardware DTP-2 also provides technical assistance and supports the design of storage facilities, including the exact calculations for instalment of required cooling power.

6.4 Assessment and Matchmaking Vietnamese and Dutch partners and results

Assessment and Matchmaking

An in depth assessment of the potato supply chain of the PC-1, the FLW hotspots and potential solutions, was conducted. The Dutch companies were selected after having gained a good understanding of the issues in this particular potato supply chain in Vietnam. In several rounds of bilateral discussions, with several representatives of the Dutch companies, the matching meetings were prepared. The project team decided that it would be most successful to have two separate matchmaking meetings. One with service provider of PC-1 (SP-1) and DIP-1 and one with service provider of PC-1 (SP-1) and DTP-2. In both meetings the agenda was comparable. The meetings started with an introduction by the project team introducing the project, the objective of the meeting, and the results and ideas so fare. The companies introduced themselves, their products, activities and their requirements. Thereafter the project team not only facilitated exchange and discussions in the matchmaking meetings itself, but it also facilitated exchange and follow up after the meetings. Where necessary, translation was provided by the project team from English into Vietnamese and vice-versa. Also in the meetings with the potato stakeholder, similar to the dragon fruit stakeholder meetings, the level of English was not always sufficient. It helped, that in the meeting between the PC-1 and DIP-1, the Dutch company invited a representative in Vietnam to the meeting.

In both meetings with the Dutch companies SP-1 explained that they grow some 1,000 tons of potato seeds every year. It produces mini tubers and then provides certified seeds to farmers. Farmers either cultivate potatoes on own farms or rent the farms in the winter season, outside the rice production period, for potato cultivation. The harvested potatoes are supplied to PC-1 for the processing of potato chips. Preferably seeds which are freely available, thus without protected rights, are used. New varieties are also tested regularly, more than 50 varieties were tested in recent years. If tests look promising, varieties are proposed to PC-1 for the final assessment. But before new varieties can be used, SP-1 needs to get an official approval as well by the Ministry of Agriculture and Rural Development of the Socialist Republic of Vietnam (MARD). Testing and approval of new varieties can take between 1-2 years. The SP-1 explained that the production faces various challenges every year.

Key problems indicated were related to uncertain quality and quantity due to for instance:

- Problems with various diseases e.g. phytophthora but also others.
- No application of good agriculture practices and no harmonization of applied practices.
- Not fully matured products because potatoes are harvested too early on rented fields in the winter season to prepare for the rice production.
- Changed raining pattern and altered temperatures.
- Sprouting and other problems of seed potatoes in the storage.

DIP-1 gave a company presentation and listened to the challenges of SP-1. DIP-1 indicated that the encountered diseases are relatively common problems. It needs timely pest control and/or reduction of the number of multiplied potato generations. However, the root causes for both problems also lay in the used potato seeds. Seeds with better resistance to the encountered diseases are suggested. Also, variety innovation, in combination with improved cultivation methods, can help to take care of the problems. In the Netherlands for instance, seed production on fields only takes place once every four or five years. Seed multiplication needs to be made on new soils and one need to be very strict on this. Also, cultivation technics can help e.g. the soil need to get prepared very well with good planting beds. In the Red River Delta, DIP-1 explained, the reality of the potato production is specifically challenging due to the short growing season combined with short days and little light. Getting top-quality raw material without using top seeds is also a very big challenge. The suggested long-term solution by DIP-1 is the development and registration of new varieties with better disease resistance and the setup of a quality control body. However, this can take a few years and goes along with considerable investments. A short-term solution is to test DIP-1's varieties with the right characteristics which are already registered in Vietnam. DIP-1 has high quality production available for testing but emphasised once more that multiplication has to go along with the right cultivation methods.

DTP-2 gave a presentation of its company and products. Under similar climate and geographic conditions as in Vietnam, DTP-2 explained, their technology allowed for up to 11 months of storage. When they started in that region, the losses in storage at that time were 26% in seed potatoes. Today, due to the technology and knowledge of DTP-2, the losses in the seed potato storage are reduced to 4-6%. In Vietnam, the service provider of PC-1 explained, losses were up to 30% or more in the past, and were reduced to currently 12-15% losses after 8-9 months of storage. Thus, 10% additional reduction of losses might also be within reach for Vietnam.
DTP-2 illuminated that they were able to change the industry via an integrated approach, looking at the total handling. In the traditional system potatoes for instance arrive at the packhouse in bags and then a hook system is applied. In this system no grading takes place, whatever potato bags are brought to the storage are also stored there. Next to that, the along going handling of the hook- and bag system leads to a lot of damage of potatoes. DTP-2 started with the introduction of the box storage system without bags. Boxes, compared to bags, need a lot less handling and therefor also know less damage. Next to that, DTP-2 installed its equipment for temperature -, humidity-, and CO^2- control, guaranteeing that the storage conditions are not only optimal but also equal everywhere in the storage. This, DTP-2 explained, is often not the case in the more traditional storage systems like in Vietnam. In DTP-2's storage settings are controlled via sensors and are automatically adjusted e.g. automatically removal of CO^2 via sensors, and automatically guaranteed of the humidity. If the humidity is not maintained well, there is a huge weight loss. Last but not least, DTP-2 explained, that it is important to keep in mind that many traditional storage systems need a lot of energy, whereas DTP's storage solutions are energy efficient.

SP-1 explained that they indeed mainly manage the temperature and no other factors, and that also the temperature varies in the different parts of the storage. Sprouting, as indicated above, was one of the problems they face in the storage. DTP-2 explained, that sprouting often occurs in traditional storage system when cooling is not creating a uniform temperature throughout the whole storage but is creating different temperature conditions.
SP-1 indicated that it is much interested in the technology offered by DTP-2 and that it would like to set this system up in Vietnam, preferably starting with a sample cold storage. However, a solution needs to get identified for the financing of such a storage. Due to the availability of limited funds DTP-2 offered assessing whether the current infrastructure can be upgraded rather than rebuild. A detailed description was provided to assess this option on its feasibility.

Technical advice: The optimal humidity level in a potato store is 90 – 92 % RH (Relative humidity). For the cooling system, it is essential to use an oversized evaporator with relatively high air volume, to limit the temperature difference (ΔT) to 2 ℃. An evaporator always will dry out the air, but the humidity loss will be less by lower ΔT. A potato tuber should be cooled down with an air stream with a temperature difference of maximal 2 ℃ between the cooling air and tuber temperature. If the difference is more, the drying effect on the tuber will increase. Industrial evaporators normally work with a ΔT of 4-5 ℃. This temperature difference can be reduced by increasing the air volume over the evaporator. To compensate for the humidity loss in the cooling system, the use of a humidifier system will be needed. In the air stream of each evaporator fan, a humidifier nozzle should be mounted.

As this option was assessed positively it led to the development of a tailored quotation. At the writing of the report the offer was not yet signed. However, the project team assumes that it is going to take place in the near future as there is much interest in setting up a first pilot storage facility.

Conclusions from the meetings and discussion

It became obvious that Vietnam has serious FLW hotspots in the potato supply chain. Still, it was very difficultly to create direct entrances and thereafter willingness at the level of the big Vietnamese potato companies to collaborate with the project team on this subject matter. The reasons for this restrain on the Vietnamese side are unclear. It could be that transparency on this subject matter, unless required by legislation, is unwanted. The focus of the project team therefor was more on upstream collaboration and interventions. The service provider of PC-1 showed big interest in better seed varieties and an upgrade of the current seed storage facilities. However, the Vietnamese company indicated that some intermediate steps are needed before business can get established. For the Dutch potato seeds, the suggestion was to test the suitability of some of the DIP-1 varieties for the crisps production. DIP-1 is willing to provide the seeds for the set of several test trials and the service provider is very interested in establishing those tests. If test results are promising, it was suggested that follow up steps should be done between the service provider, PC-1, DIP-1, and the representative of DIP-1 in Vietnam. To be successful, it was indicated, a team and collaboration between those upstream- and downstream actors is needed. Also the rights of DIP needs to be assured of protection. With regard to the upgrade of the storage facilities all needed details of the current storage facilities were shared. DTP-2 made a tailored offer for a first pilot storage and the service provider of PC-1 indicated that it would consider expansion after the evaluation of the efficiency. Thus, although several months were needed for this work as various hurdles had to be solved, the result looks promising. With two Dutch companies, first steps towards potentially long term FLW reducing collaborations were realized.

Although it was found that Dutch technology and knowhow can help finding FLW reducing solutions and prolonging the storability of potatoes in Vietnam, the project team saw from the discussions, that a potential decision on concrete investments goes in small steps. Before Vietnamese companies are likely to take a decision, they want first to see the advantages and preferably they want to have a local representative on the ground. Establishing proof of principles on the real impact of Dutch FLW reducing technologies and knowledge could be supportive for the next steps and broader uptake and scaling. It was observed that availability of funds for these investments can be bottlenecks. Ideally, to enable faster steps, funds should be made available to build the proof of principles. To boost future initiatives in this field, it should be considered to increase the scale via for instance a whole sector approach in multi-annual projects.

7 Investment conditions for Vietnamese companies on FL reduction

The project team launched and executed a small survey under five Vietnamese companies to get a better understanding of the conditions under which the selected leading Vietnamese companies would go into the investment of Dutch technology. The results of this survey are:

- Vietnamese companies recognized the benefits of advanced technologies in reducing FLs and are willing to invest in new technology from foreign countries. They indicated that they preferred imported technologies from European countries to the neighbouring countries (e.g., Japan, Korea, and China), as they considered the quality of the equipment more important than the price. All interviewed parties had experience with working with foreign partners on projects or activities.
- The directors of the companies are in charge of taking the investment decisions. In Vietnam, many exporting firms are family-owned, and the CEOs have the foremost right decision-making. They mostly have good financial status and money set aside for investment in technology and do not depend too much on loans from banks. The institutes, that are providing the seed potatoes are 100% autonomous and can make their own decisions. As the institute's own investment capital is limited, they depend on other sources for investment. They are therefore interested in cooperation with private companies (including companies from abroad) in investments in the form of sharing benefits, rights, and obligations or wish to receive the concession loans from international organizations for their agriculture projects. They do not require permission from the government for that.
- The factors indicated by the private companies to be considered the most when going into investment of for instance VND 1 billion[29] are: economic growth, technological developments (productivity of capital), and market demand for the products. Currently, as a result of unpredictable situations that may happen due to the impact of Covid-19, companies indicated that they are hesitating to invest. With respect to investments in cold storage, the Vietnamese companies indicated that they felt more confident working with companies that: have good references, offer equipment with efficient energy use and advanced technology, and have a good guaranteeing policy. Notably, all companies indicated to care much about this guaranteeing policy. They also revealed that they prefer companies having a representative office in Vietnam to support them immediately when having problems over those with no representative office in Vietnam. The availability of personnel for installation is not a big problem as they can arrange for their technicians and interpreters to work under the guidance of foreign experts from partner companies (results based on a survey with Vietnamese companies, Q1 2022).

7.1 Lessons learnt based on experience and interviews with companies

The project throughput time was two years. The second phase of the project was extremely useful, since very often studies reveal opportunities, but hardly support the stakeholders in the road towards implementation. This process towards investment decisions and business agreements on FLW reduction has led to practical guidelines and learnings that are useful for both Vietnamese and Dutch stakeholders. This information is undervalued and should be recognized as knowledge as well, besides e.g. all the impact calculations and identification of product- or technology related opportunities. A summary of the experience of the project team is provided here:

- 'Traditional' small to medium sized Vietnamese companies' do not have the investment space to invest into Dutch FLW reducing technologies. Also, their priorities in order to reduce FLW should be

[29] 1,000,000,000 VND-Vietnamese Dong are equivalent to ~ 42,900 US$, Xe currency converter, viewed 7/7/2022

first on the implementation of good practices and the shift from a 'push-market approach' to a 'pull-market approach'.

- Assessing potentially interesting companies for this project in Vietnam took a long time, needed a big pool of companies and finally a lot of persistence to identify at least 1 company per selected product category with interest.
- Dutch technology companies come to Vietnam or elsewhere with their technology only. That means, that the demanding entity in Vietnam should already know that they want their technology and have access to finance. However, we have seen that the parties in Vietnam do not know yet what kind of technology the Netherlands exactly has to offer and what the advantage of Dutch technology is compared to technologies from elsewhere, like USA, Japan or Australia.
- Although the proposed investments are sometimes high, it did not cut off the discussion between the Vietnamese and Dutch partners. The Vietnamese companies both for dragon fruit and potato even want to pay for small pilots showing the proof of principle.
- The first impression was that Dutch technology is more expensive than local/regional technology. The added value and mid-/long-term benefits of Dutch technology compared to other technologies is hard to demonstrate in meetings especially since similar and cheaper technologies are available and there are no demo projects in Vietnam.
- Communication between Dutch and Vietnamese companies could not go directly, it often needed translation. Without local entrances in Vietnam, it will be difficult for Dutch companies to enter the market. A local representative understanding the local culture, language, business reality, as well as other relevant circumstances is of importance.
- FLW reduction needs an integrated approach, starting with the right seeds/propagation material (see potato, but the same goes for dragon fruit).
- Although our project established direct links between Dutch and Vietnamese businesses it is uncertain whether those will be continued and mature into business relations without further guidance and support of the actors and the building of concrete 'proof of principles' showing advantages of Dutch technology and knowledge (beyond the scope of the project).
- Nor Dutch nor Vietnamese companies were super pro-active and pushing for the next step/meeting (e.g., sending emails to us, call us). Both waited for the other party to do the next step. Thus, to establish new business relations it really needs independent facilitators understanding both cultures and business realities and bringing parties together.
- So far, there is little known about the post-harvest physiology of dragon fruits. It is also not clear yet how/if dragon fruit reacts to e.g., CA and other shelf life extending techniques and practices. Also shelf life and settings seems to be different per variety.
- External factors like the increased sea freight costs (sea- and air freight cost more than doubled the last months) and the unpredictable lead times - both resulting from the outbreak of Covid - are unfavourable for the stimulation of export to Europe for highly perishable products.
- Introduction of better seeds should go along with simple low-cost procedures for the registration of seeds and good protection of the rights of the registered varieties. Also, the government has a role in the establishment of quality control system for varieties. Currently, the process of new variety introduction takes several years and is very costly, and is therefore not an easy intervention.
- In the context of Covid-19 with lots of challenges in market demand and logistics, companies do not have much interest of expanding/ boost market in EU as the transport costs and risks are too high.

8 Policy advice for a Roadmap on PHLs reduction in Vietnam

The Netherlands

Projects on FLW from the Dutch government are relatively small in budget and throughput time. In that context it is difficult to achieve a business agreement between Vietnamese and a Dutch (or any foreign) company as a project goal. It is recommended to profile LNV as an enabler of FLW reduction by on the one hand knowledge transfer (FLW monitoring, analysis and interventions) and on the other hand intermediary between Dutch supplier of FLW reducing technologies and Vietnamese (and other countries) project stakeholders[30]. It is crucial to include the following into the ToR for new FLW projects:

- Commercial contracts cannot be achieved within the project, but a proof of principle via demos showing the baseline scenario versus the improved scenario (including the business case) is not only possible, it is merely a necessary condition for follow-up between stakeholders. Developing a fact-based narrative under local conditions in combination with low investment costs (for the demo) and strong commitment between commercial partners is likely to evolve if the pilot is a success ("seeing is believing", see a successful example in the text box right)
- Integrated approach including: the whole supply chain, improved seeds/propagation material, best practices along the supply chain, protocols, training, business planning, access to finance
- Although FLW reduction is the main target of the Dutch ministry of Agriculture, Nature and Food Quality, the impact is likely to be more successful if the framing of the topic is businesswise. In many cases improvement of the food supply chain performance leads to FLW reduction. Hence, impact on FLW reduction can be achieved in many ways, and as long as the intervention leads to significant (and proven) FLW reduction policy makers and business partners both achieve their goals.
- Convince stakeholders (by examples) that FLW reduction will often go along with and/or is a consequence of other benefits like shelf life extension.

Example of a successful Proof of Principle reducing Food Losses in Rice in Nigeria via the introduction of Mechanisation

In the rice supply chain in Nigeria, after identification of hotspots and longlisting of interventions, mechanization of harvesting and threshing were selected as highly potential loss reduction interventions. Those two interventions were implemented and assessed on their real impact. During one rice season the yield from mechanically harvested and threshed sample plots of rice was measured and compared with the yield measurements from sample plots harvested and threshed manually. Based on this pilot, which took place under real circumstances in the fields of smallholder farmers, it was shown that introducing mechanized harvesting and mechanized threshing prevents almost half a ton (479 kg) FL per hectare. Mechanization also increased farmers income by approximately 200 US dollars per hectare. Moreover, the introduction of mechanization can avoid 1.7 ton CO2-eq. production-related greenhouse gas emissions per hectare. This already accounts for fuel use of the reaper and thresher, making a strong case for farm mechanization as a climate positive intervention. The total costs of a mechanization program - machinery, infrastructure, training, setup, annual overheads and depreciation - was equivalent to ~ 34$US per farmer served, corresponding to an annual ROI of ~ 10. Based on this work, the researchers gave among others, the policy advise that mechanization should be part of agricultural development strategies for reducing losses, improving food security and improving farmers' incomes. In the context of these strategies, mechanization should be approached from a broader value chain perspective, with early involvement from all relevant stakeholders. It was recommended to cooperate with existing initiatives for improved practices in rice farming.
For more information please consult the publication [1].

[30] Currently, a study with an overview of Dutch companies and their technologies is carried out by RVO

Vietnam

Reducing FLW is a big concern of the Vietnamese government. In 2018, the government of Vietnam approved the National Action Plan on Zero Hunger in Vietnam towards 2025. One of the targets of the national plan is that by 2025 "food will not be lost or wasted". On March 22nd, 2021, The Prime Ministry of Vietnam has issued the Decision 417/QD-TTg approving the project of development of the vegetable processing industry for 2021-2030, in which the goal by 2030 is to reduce post-harvest losses of vegetables and fruits by over 1.0%/year. Currently, Vietnam has very high food losses [9, 10]. Our advice is therefore to define a roadmap according to the Target-Measure-Act approach from Champions 12.3[31]:

a) Target: first of all targets on FLW reduction (SDG 12.3) are necessary as a starting point for policy making and set realistic goals.
    - A target is set for vegetable processors only (see text above), but more supply chain links and food categories should be involved. Especially farmers are important, since this project showed that much losses are caused by low quality at the start in the supply chain at farm level.
    - Prioritize targets and provide timelines.

b) Measure: literature on FLW in Vietnam is scarce. Although various sources claim significant losses, the size is unclear in weight and value. Targets often are put in % FLW reduction, and without data on FLW it is unclear how much effort and support is required to achieve the goals. Moreover, real data provide more awareness for the stakeholders involved.
    - Absorb and provide knowledge on FLW measurement methodologies. For many years, FLW methodologies were developed. For the purpose of this project WFBR's EFFICIENT protocol was applied and could be further scaled to other food products. An overview on the various available methodologies is given below:

Table 3: overview of FLW quantification methodologies [3]

Organization	Name of methodology
WUR/WFBR (2021)	the EFFICIENT protocol
CEC (2019)	Why and how to measure food loss and waste: A practical guide.
FAO (2018a)	Global Food Loss Index (GFLI).
FAO (2018b)	Guidelines on the measurement of harvest and post-harvest losses: Recommendations on the design of a harvest and post-harvest loss statistics system for food grains (cereals and pulses).
UNEP (2020)	Food Waste Index (FWI)
WRAP (2018)	Food waste measurement principles and resources guide.
IFPRI (Delgado et al. 2017)	The reality of food losses: A new measurement methodology.
EU FUSIONS (Tostivint et al. 2016)	FUSIONS Food Waste Quantification Manual to Monitor Food Waste Amounts and Progression
WRI (2016)	Food loss and Waste Accounting and Reporting Standard.
GIZ (2015a)	Rapid Loss Appraisal Tool (RLAT) for agribusiness value chains: User guide for maize
UNEP (2014)	Prevention and reduction of food and drink waste in businesses and households: Guidance for governments, local authorities, businesses and other organizations.
APHLIS (Hodges 2013)	African Postharvest Losses Information System (APHLIS) and How to assess postharvest cereal losses and their impact on grain supply: rapid weight loss estimation and the calculation of cumulative cereal losses with the support of APHLIS.
Rockefeller Foundation (2016)	Yieldwise Food Loss Initiative.

    - The government can support knowledge transfer from all over the world, by engaging international stakeholders and frontrunners like UK, the Netherlands and USA. The UNFSS (United Nations Food Systems Summit) provides an excellent platform to do so. Targets are already set for some stakeholders in Vietnam, but monitoring not only the weight loss, but also the corresponding value loss, is necessary to involve the private sector and many tools are already available.
    - Support projects that will provide insight in hotspots in value chains across all food categories. Since methodologies are available already required finance can be limited. Moreover, besides national funding, cooperation with world leading funders is an option.

[31] https://champions123.org/publication/call-global-action-food-loss-and-waste, viewed 11-4-2022

c) Act: once the hotspots are identified in the 'Measure phase', action is necessary. Here also, tools are available in the context of engaging the private sector, as well as insight in the interventions that might fit the best in the local situation to reduce FLW.

- Stimulate big companies to set the example following the 10x20X30 initiative. 10x20x30 | Champions 12.3[32] (bring together 10+ of Vietnamese's largest food retailers and providers, each engaging at least 20 suppliers to halve FLW by 2030). The FLW data collection methodology applied in this project, for measuring and monitoring as well as for hotspot identification and intervention selection, could be used.
- It is clear that much FLW arises because the quality of the seeds at the beginning of the supply chain at farm level is suboptimal. To solve issues at this hotspot for fruits and vegetables Vietnam should overcome some hurdles going along with the registration of improved seeds, royalties should get protected, and Vietnam should establish a quality control system to protect royalties and control the purity of varieties.
- Investments are possible mainly in demand and quality driven supply chains e.g., via massive training of farmers and supply chain actors, support with the establishing of pilots and the dissemination of knowledge.
- In Vietnam in many cases there is a language barrier. Especially doing business outside Asia requires good communication skills in English. If Vietnam wants to become an important player in fruit and vegetable export worldwide this communication gap should be closed. Also, the government could transfer knowledge by translating various relevant methodologies into Vietnamese.

[32] https://champions123.org/10-20-30, viewed 11-4-2022

9 Conclusions

Phase 2 of the project was aiming for impact. Not only the interventions with the highest potential were inventoried, but also companies were connected and ultimately quotations were exchanged. By extending the project from technical and financial analysis towards investigating the business process between Vietnamese and Dutch companies, the project team believes to add new value in order to increase FLW reduction. Specific conclusions from Phase 2 are:

1. To increase impact FL reduction should, along with environmental advantages, be framed as a business opportunity.
2. The climate control of dragon fruit is managed historically for maximum two weeks of shelf life (markets like South East Asia, Japan, USA, Australia). To enter the EU market air freight is too expensive, and the boat takes at least 26 days (in these days close to 35), implying a new technological challenge. Experiments and pilots are required to extend the shelf life.
3. To connect to the EU-market with dragon fruit (by reducing FLs with sea transport) good communication in English is necessary. In operations this is a must as well. In this project five of the largest food exporters/companies were involved and the language was always a hurdle.
4. The potato value chain at hand is suboptimal in the context of the grown varieties in relation to the processing end product. In spite of that, first, the Vietnamese seed potato supplier investigates a cheaper and quicker solution in the context of cooling. A change of variety takes a long time and is expensive. A pilot with a Dutch variety is under investigation though.
5. For potato as well as dragon fruit much is to gain at farm level. Finding the right varieties, vertical integration, training and carrying out pilots with different climatological conditions is key. For dragon fruit, aiming for the EU market, it is probably the first step necessary to supply fresh produce of constant good quality.
6. Vietnamese companies said that they have demand for facilities with advanced technology from European companies, and Dutch companies are willing to work with them to supply the facilities. Nevertheless, it was observed by the project team, that it was difficult for the Vietnamese companies to make the progress without the lead of the project team as soon as it came to the step that needed the independent collaboration of the two companies. The reasons for this might be related to the above-mentioned factors. Bringing the Dutch technology via proof of principles in Vietnam closer to the Vietnamese companies, can be also supportive in the context.

Although the project connected Vietnamese and Dutch companies the follow-up is still unclear. The interventions have been made concrete including business offers, but it is beyond the scope of this project to include implementation. When push comes to shove the financial situation and position of the Vietnamese companies will show their real involvement, and the project stakeholders know that sometimes unknown issues can play an important role in this process. For now, all signs are green and it’s up to the companies.

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Annex 1 The EFFICIENT protocol

Quantifying FLW is essential for identifying hotspots in FLW and assessing effectiveness of FLW reducing interventions and system changes. Measuring is one of the means to identify the hotspots to select the most appropriate FLW reducing interventions. However, measuring is time, data and resource intensive, which prevents broad implementation of FLW monitoring. Considering that the overall goal is FLW reduction, Wageningen Food & Biobased Research (WFBR) has developed 'The EFFICIENT protocol' allowing to move faster to the implementation of interventions than many traditional approaches which often require substantial means and time to collect FLW data via direct measurements at all stages of the supply chain, without differentiating whether all the stages are critical control point for losses/waste or not. The WFBR approach includes a pragmatic protocol for PH FLW monitoring. Key asset of this protocol is the reduction of direct measurements and data collection to the most essential (for instance the stages with high FLW or uncertainty on FLW, or stages which have been identified as being of high risk in the supply chain) and use of secondary information or expert-estimates for missing data. It is intended to boost FLW monitoring (lowering drawbacks mentioned above) and to help pointing out causes and potential interventions for FLW[33]. The EFFICIENT protocol does not require an integral assessment of all the steps, but enables the user to apply whatever suits the particular case at hand.

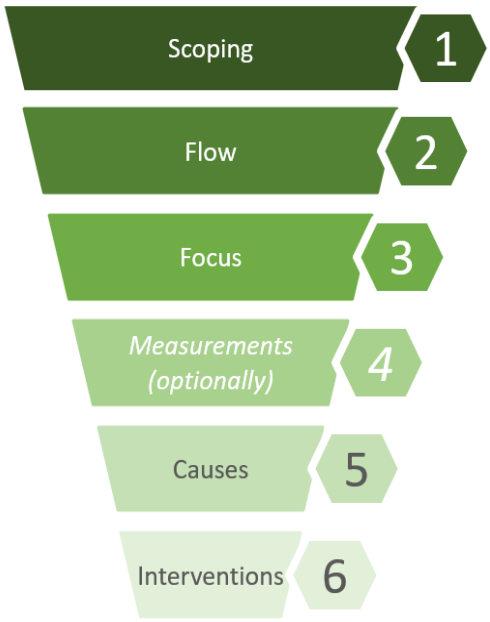

Figure 2: steps in EFFICIENT protocol

The full EFFICIENT protocol is available via this link https://www.wur.nl/en/research-results/research-institutes/food-biobased-research/show-fbr/consortium-for-innovation-in-post-harvest-loss-food-waste-reduction-f00dwa5.htm

[33] https://sites.google.com/iastate.edu/phlfwreduction/home/efficient-food-loss-waste-protocol, viewed 30-4-2022

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Report 2330

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