Reducing postharvest food losses in developing economies by using a Network of Excellence as an intervention tool

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Abstract

Value chains for perishable products, including fruits and vegetables, require an integrated approach to cope with the challenges in producing sufficient food products in a resource-efficient manner. Developing economies are increasingly investing in their potential of agricultural production; however the absence of a sufficient and functioning infrastructure in the postharvest chain results in large shares of harvested product being lost before reaching the consumer market. This study provides clear analysis of the causes of these postharvest losses and suggests the development of effective interventions that form the nucleus of the network of excellence in support of chain actors to improve performance, increase efficiency and provide good quality food products in local and global markets.

Key words

postharvest losses, value chain, fresh produce, food security, resource efficiency, network

Interventions for the reduction of postharvest losses in developing economies: value chain approach through a network of excellence

Introduction

This paper forms the excerpt and the follow-up on a study on the reduction of postharvest losses[1)] in developing economies that was conducted by science departments of Wageningen UR.[2)] The purpose of the study was to assess the feasibility of designing a multi-stakeholder intervention that will contribute to the reduction of these food losses (Van Gogh, 2013). The conceptual idea for this research originated from the so-called Dutch triangle, consisting of partners from respectively the public, private and scientific sector, each of them having their own motivation or interest in minimising losses in the postharvest chain and to contribute to the development of interventions that will improve food security on a local and global level.

Problem Statement

Various studies on postharvest food losses support the view that interventions for the sustainable reduction of these losses have to be planned within the context of the relevant value chains. The use of a holistic approach towards value chains has become an acknowledged method to define such interventions that are effective in local, regional and international supply chains (AUC-FAO, 2012). In order to make improvements the mere introduction of technical infrastructure or innovative measures does not suffice, but also requires awareness creation for problems and training in postharvest management combined with solutions in their specific environment. The latter refers to the economic environment (supply chain vs. market), as well as to the political and social/cultural environment. In other words, interventions need to be developed within the context of or connected with these environments.

Objective

The idea that a conglomerate of stakeholders, rather than a single party would engage more effectively with the complexity of causes of postharvest losses (PHL) forms the basis for the initiative by the government of the Netherlands and Wageningen UR to develop of Network of Excellence for the reduction of PHL. Such a network will also encourage and facilitate co-operation between stakeholders from the private and public sector, and from science and education institutes.

The research investigated the causes of postharvest food losses in developing economies and the feasibility of an intervention by using a Network of Excellence (NoE), and the design of such a network. The product scope of the network and with that the research is confined to the product group fruit and vegetables (including roots and tubers). The reason is that for perishable products in general, losses between harvest and consumption in developing and emerging economies[3)] are

[1)] Whereas the term 'post-harvest losses' refers to the losses in quantity and quality after harvest and before consumption.

[2)] Wageningen UR Food & Biobased Research (FBR) and Wageningen UR Agricultural Economic Research (LEI).

[3)] The term 'emerging economies' is used for countries that in their phase and pace of economic development are different from high- resp. low-income countries. In terms of developed and developing economies these countries

high and even higher than for cereals, though they vary by region and type of product. Losses over 50% are suggested (FAO, 2011). Furthermore, fruit and vegetables are gaining importance in local and global supply chains, generating revenues from export and increasing consumption in local markets. This paper is based on the research that was conducted and intends to gain insight in the causes of postharvest food losses in developing and emerging economies, the fields of expertise identified as relevant for the network, and the conceptual design of the NoE.

The remainder of this paper is structured as follows. First, some background information regarding the global trends and drivers are discussed. Then the methodology used and results of this study are detailed and discussed in turn. Finally, a discussion of the findings is presented.

Background

Trends and drivers in global food security

The central question of the study is how supply chains in economically developing countries can be strengthened and improved to enable food production in an economically, environmentally and socially sustainable way so that food losses will be decreased to a minimum. Over the past years the focus on PHL has gained momentum as a precondition for the overall growth in productivity of supply chains. This growth is necessary to increase global food production. Within this context a supply chain can be seen as a large system comprising several subsystems (organisations) together with the relationships between them. A supply chain refers to a series of (physical and decision making) activities connected by material and information flows and associated flows of money and property rights that cross organisational borders (Van der Vorst, 2000). It not only includes the manufacturer and its suppliers, but also transporters, warehouses, retailers, service organisations and consumers themselves (Van der Vorst, 2014). Food supply chains comprise organisations that are responsible for the production and distribution of vegetable or animal-based products (Zuurbier, 1996). Graph 1 shows a schematic example of a supply chain for fruits and vegetables, with its succeeding activities and their effects on the product economic value (costs) and consumption / use of energy.

The term value chain is also often used in the discussion on improving performances of food production systems. A value chain refers to the full range of activities that are required to bring a product from conception through the different phases of production to delivery to final consumers and disposal after use (Kaplinsky, 2001). The broad approach of defining value chain looks at the complex range of activities implemented by various actors (primary producers, processors, traders, service providers) to bring a raw material through a chain to the sale of the final product (M4P, 2008). In discussions the terms value chain and supply chains are quite often disorderly used. In this paper supply chain refers to the set of activities within a chain, while value chain is used as the systematic way (value chain approach) of examining the activities of not only one individual company, but also the activities of component companies within a supply chain (Van der Vorst, 2000).

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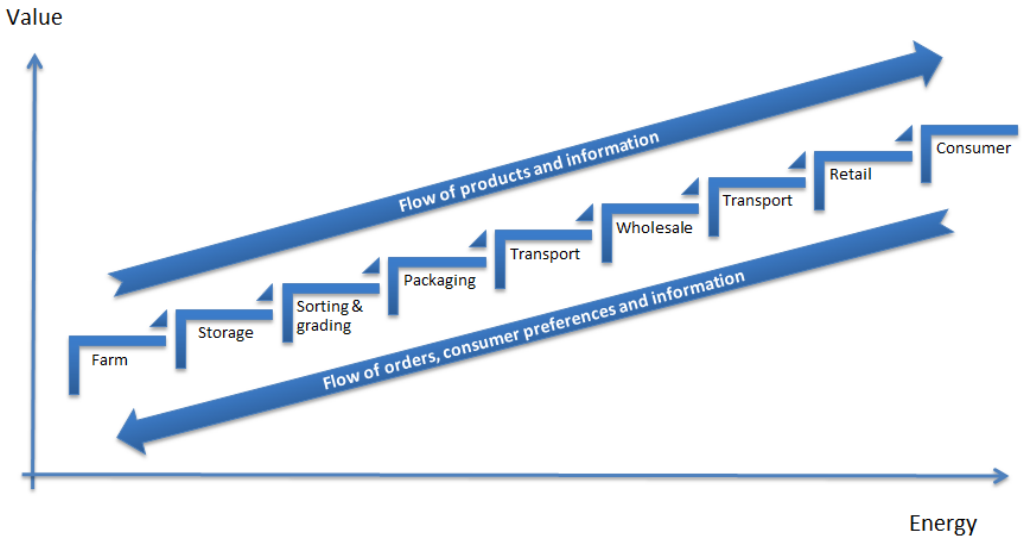
are somewhere in between, but as a group is also very diverse. In terms of quality and maturity of supply chains for perishable products, emerging economies are considered as developing, leaving ample reason for focussing efforts on reducing postharvest losses.

Graph 1 - Steps and incremental effects in the supply chain, (value-wise and energy-wise)



The challenge not only lies in producing sufficient quantities of safe food products for a growing population, but also to realise this shift in production in sustainable manner that will take into account the efficient use of the resources that are available. This challenge is connected with the fact that in past decades supply chains for agrifood products have grown more complex and will continue to become more complex as pressure to produce food that is of good quality and safe, and that will be sufficient to meet (future) global demand will increase. The pressure is felt in extremis in developing economies where generally food security is not self-evident, and where availability, accessibility and affordability of food products are likely to be influenced or constrained by the following drivers or trends:

1) *Demographic development* in general form an important driver for food production, but the world population prognosis (medium growth scenario) by the year 2050 peaking at 9,3 billion is significant in particular as a substantial part of this growth will be in Africa and Asia. *Urbanisation* forecasts show that an increasing percentage of the world population will live in urban areas. Today, half the world's population lives in urban areas and over the next decades almost all population growth will be urban. Again, urbanization is particularly rapid in sub-Saharan Africa and East Asia, which have urbanization rates greater than 4 percent and 3 percent respectively. By 2050, about 70 percent of the global population is expected to live in cities. By itself this will have important consequences on consumption patterns and food supply chains.
2) *Food prices* will grow to be more *volatile*. Escalating food prices in recent years put pressure on already difficult access to food for many people in developing countries. Projections of food prices by the World Bank indicate that food prices may rise 30 to 50% in the decades to come. FAO has called it a new era of international food price movements that is characterised by high levels of nominal and real (deflated) prices and unprecedented volatility in price movements (FAO, 2012). Higher prices and increased volatility are products of strong demand drivers such as economic growth and shifting dietary patterns in developing economies, and changing biofuel policies throughout the

world. A strong supply response is, however, not expected soon. This will bring about a shift in the global food system, inducing an intensified battle for agricultural commodities (Rabobank, 2011).

3) *Shifting trade patterns and income growth* form another trend. The internationalisation of trade has substantially affected the complexity of (food) supply chains. The sourcing of fresh fruit and vegetables has become a global network. Horticultural crops play an important role in the economy of developing countries and in international trade. Where supply chains in Western countries are shifting more and more away from local suppliers to the global arena, trade companies increasingly invest in supply chains abroad and in securing a steady supply of good quality product. Even where farmers remain linked only to domestic markets, those markets are like to change, partly in response to changes in demand (reflecting income growth and urbanisation) and supply (competition from global markets absorbing more domestic production) (Gordon, 2012).
4) *Highly concentrated agro-industrial firms and retailers* have an increasingly dominant role in food systems. Increasing retail power is not confined to developed countries (Gustavsson, 2011). As Kitinoja states 'the entry of modern retail players, both international and domestic, into developing countries and transition economies is bound to continue having major impacts on these countries' agrifood systems, as large-scale supermarket retail and wholesale operations demand large-volume and low-price produce that meets stringent quality and safety standards' (Kitinoja, 2011).
5) A shift of lifestyles and diet patterns of the *rising middle class* in emerging economies will give rise to the shift into higher protein products. MGI made the prognosis, that in the next two decades to come up to three billion more middle-class consumers will emerge worldwide, mainly in China and India. The demand in the developing countries for other food products that are more responsive to higher incomes (such as livestock, dairy products, vegetable oils) will grow much faster than for cereals (Dobbs, 2011).
6) The increasing *scarcity of resources* (land, water, energy, nutrients) forms another pressing restriction to the capability and capacities to produce sufficient and affordable food products. The reduction of the supply chains' ecological footprint and environmental considerations concerning food losses and valorisation of waste streams are addressed by several stakeholders (HLPE, 2014).

Postharvest Losses: a holistic value chain approach

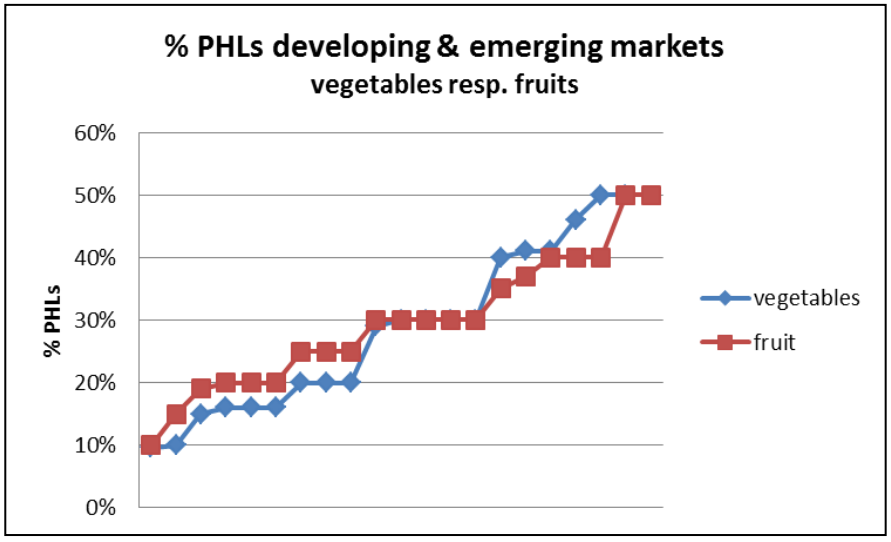
From the previous can be concluded that global economic development is increasingly putting pressure on the production capacities of food supply chains and on the capability to have sufficient food quantities at the right place at the right time, safely and with a price and quality that is accepted in the market. Constraining in this is that the productivity of resources will have to be improved in order not to compromise the ability of future generations to meet their own needs[4)]. Reducing food losses has been ranked by MGI third in a top fifteen list with possible resource productivity measures that will contribute to improved productivity of resources (Dobbs, 2011).

[4)] Derived from the Brundtland Commission definition for sustainable development (United Nations, 1987).

Whereas food security is on the top of the global political and scientific agenda's there is also increasing awareness of the environmental effects of improvements in food security. Food losses have an impact on food security for poor people, on economic development and on the environment and when reasoning along the same line it is arguable that efforts in reducing food losses, including postharvest losses, will have a positive effect on food security (Gustavsson, 2011; Escaler, 2011).After all, the numbers on food losses and food waste lead to the suggestion that reducing losses and waste in agricultural and food systems could relieve part of the pressures on scarce resources and enhance food security (FAO, 2012; UNEP, 2012; Guyomard, 2012). Assessing precisely the current status of global food security is challenging, (the big picture is that approximately 842 million people are chronically undernourished (FAO, 2013)). The quantification of the impact on food security from measures that contribute to the reduction of PHL, will have to be substantiated by further (empirical) research.

Postharvest losses refer to the measurable quantitative and qualitative food loss in the postharvest system. The phrase 'measurable' is a rather complicated aspect in assessing the volume and scale of PHL in developing countries. In fact, estimating PHL in the past has proven to be difficult and not very reliable. Measuring what has been lost implies that it is known what was there at the start and this is usually not the case. PHL in developing countries are relatively unknown and when quantified are mostly referred to as guesstimates (as best-guess-estimates) derived from questionnaires rather than actual measurements (Hodges, 2010). For perishable products (vegetables, fruit, roots & tubers), only little (representative) data are available.

Graph 2 - Percentages postharvest losses in developing and emerging markets



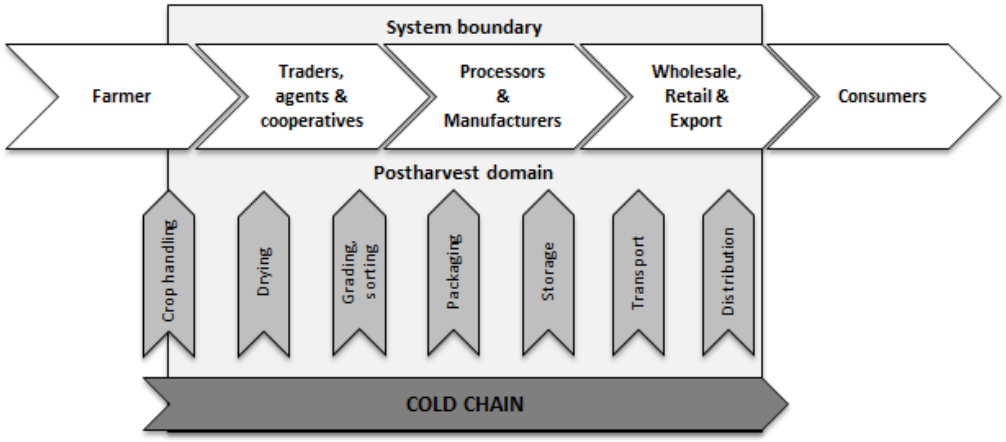
Postharvest loss figures that are most commonly used are derived from the 2011 FAO report indicating a loss of 25-40% arising between harvest and pre-consumption (Gustavsson, 2011). The data that have been retrieved from the literature review confirm this range, albeit that the lower value for percentage PHL of fruits and vegetables is estimated to be somewhat lower (20% for fruits and 15% for vegetables, as indicated in graph 2).

The underlying assumption is that reducing food losses in the postharvest chain will add to optimising the set of conditions for improved food security in developing economies, thereby

contributing to sustainable livelihoods. In this the postharvest system comprises interconnected activities from the time of harvest through crop processing, marketing, until the moment of sale to the final consumer. The fruits and vegetables postharvest chain may include crop handling, transport, postharvest operations, drying, storage, sorting, grading, packaging, wholesale, distribution, and retail. In general the postharvest system includes all stages in the chain where the activity or service is intended to add value to the final product.

Food loss refers to the decrease in food quantity or quality, which makes it unfit for human consumption. In most cases this occurs as a result of untimely or improper methods of harvest, storage, distribution, processing, sales or consumption. *Food waste* is food that is not consumed and discarded as waste at some point in the product chain. The term *postharvest losses* is often used to describe "losses between harvest and the onward supply of produce to markets and equates broadly with waste in the food supply chain" (Parfitt, 2010/2011). In all cases food is lost as a result of imperfections in the postharvest chain, and/or due to sub optimal performance by actors in the supply chain. Imperfections may arise from the absence of facilities and infrastructure (technical) or can be market imperfections, related to institutional factors. In all cases these food losses are referred to in this paper as postharvest losses (PHL).

Graph 3 - Postharvest system vegetable and fruit supply chain



Mrema argues that postharvest systems in the 21st century have grown more complex compared with the 20th century, and therefore interventions to reduce PHL will have to cover this entire system and not parts of it (Mrema, 2012). This is particularly relevant as in developing economies most of the losses occur away from the farm, especially for perishables. This complexity can be observed from, amongst others, the impact from the earlier mentioned trends on agricultural and food systems as summarised in the table below, and is partly derived from Van der Vorst, 2014.

Developing solutions to reduce PHL requires insight in this complexity, including the different levels and stages in the supply chain where these solutions are to be adopted. This study intended to make a contribution to gaining this insight and to develop an intervention tool that will deal with this complexity.

Table 1 – Trends and impacts on agrifood supply chains

Megatrend:	**Impact on agrifood supply chains (and postharvest system):**
• Global population growth, urbanisation	○ Scaling up and optimisation of food supply chains, necessary in order to increase productivity and efficiency in output ○ Exodus of population from the rural areas endangers the capacity to produce sufficient food for the cities, and requires new integrated concepts of food and biobased production (i.c. agroparcs, metropolitan food clusters) ○ Expanding cities with poor infrastructures offer challenges to distribute food in the cities
• Growing middle class	○ Increasing welfare and hence changing dietary patterns increase demand for high protein products (i.c. meat, dairy) ○ Consumers become more demanding and critical, asking for good quality food products.
• Scarcity of resources	○ The decreasing availability of land and water per capita requires to invest in improved agrifood production systems ○ Limited availability of fossil energy will require innovation in new (renewable) energy, specifically for cold chain development ○ Valorisation of waste streams from agro and food production require redesign of supply chain concepts (circular economy)
• Safety, quality and sustainability of food	○ Consumers become more critical towards safety and reliability of food products. Tracking and tracing systems increasingly affect product acceptance in markets ○ Sustainability issues in supply chains become more important as consumer demand fair products and corporate social responsible conduct by actors in the supply chain (i.c. carbon footprint / food miles, water foot print, animal welfare, fair trade / fair employment, a.o.) ○ Governments impose stringent requirements to minimise environmental effects to combat climate change
• Internalisation of trade and markets	○ Increase of price volatility of raw materials ○ Increased standardization of IT systems and data sources, as well as containerization allows virtual doing possibly resulting in global sourcing and distribution of long complex chains as a result ○ An ever increasing number of smaller (international) companies in every link of the chain dominates the market ○ Increased focus on sustainability, however, also leads to regionalization, buying products from the region preferably produced on a small scale and close to nature.

Methodology

The first part of the research consisted of an extensive inventory of available scientific literature and reports (publication year: 2000 and onwards) and reviewed on their content on PHL in fruit and vegetable sectors and the specific causes of these losses in developing economies. The output of these reviews was then categorised by using a matrix structure in order to assess the main – and subcategories of PHL causes. The result of the literature review was to gain insight in the number of registrations of the occurrence of specific PHL causes, and with

that a relative ranking of these categories in terms whether specific PHL causes are mentioned more or less often as affecting the performance of specific postharvest chains.

The second part of the research involved the canvassing and interviewing of experts and potential stakeholders from the private sector and knowledge institutes that in one way or another are involved in fruit and vegetable supply chains. The purpose of interviewing representatives of these groups was to gain insight in the current practice and steps to be taken to have impact on the reduction of PHL. The interviews also served the purpose of connecting with the ideas, views and possibilities of the different stakeholders as input for the modus operandi in the NoE that would effectuate solutions in the reduction of PHL. Several stakeholders, including local business entrepreneurs and agricultural attachés were interviewed and invited to express their experiences and insight in PHL in developing economies. Representatives were interviewed either on location or by telephone, by means of a formulated script. In addition a number of feedback and work sessions have been organised with stakeholders from private and public sector, and from knowledge institutes with the objective to facilitate the process of co-designing in building the NoE. Output from these sessions have been used for the development of the conceptual design of the NoE and ultimately of the organisational and business model of the network.

Results

Postharvest loss causes

When reviewing all case studies and relevant literature the following several varying causes of PHL losses in the fruit and vegetable supply chain in developing and emerging markets were inventoried and subsequently grouped into 66 specific subcategories and a total of 14 main categories. A selection of these subcategories and the main categories are listed in table 2.

Table 2 – Categories of causes for postharvest losses

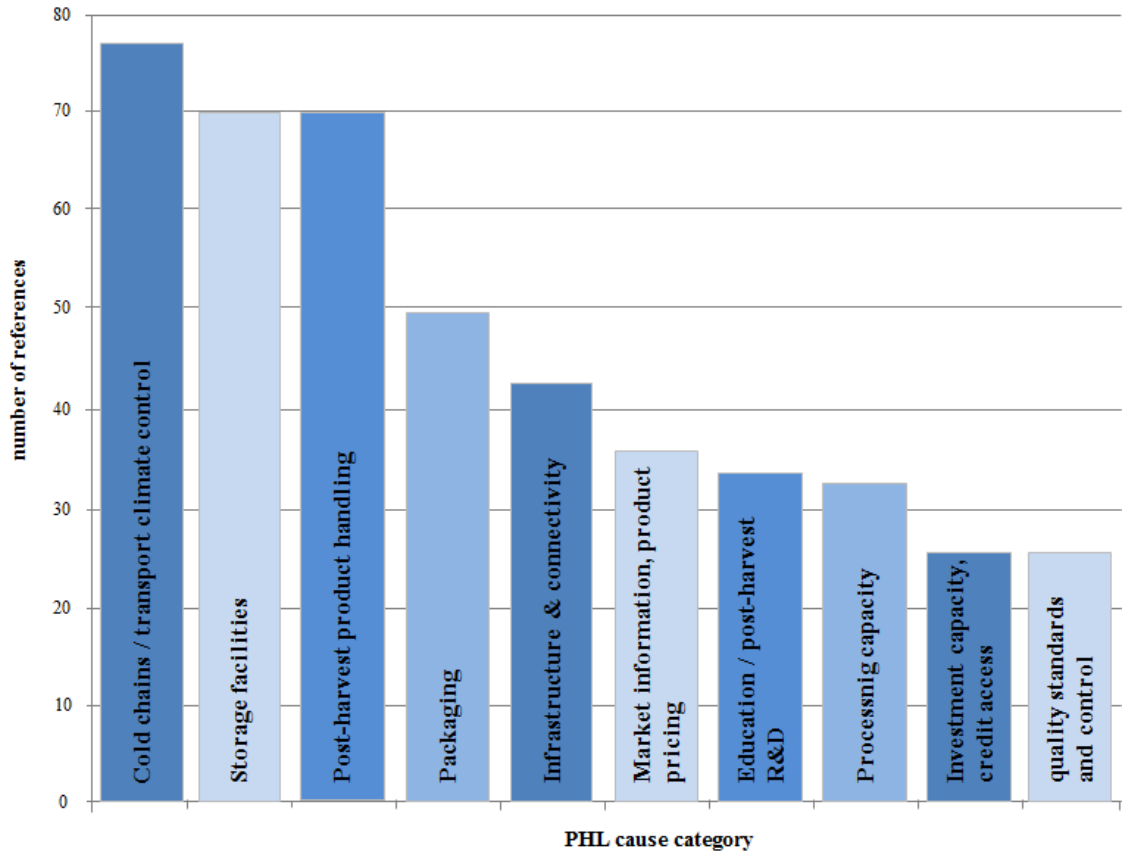
Main category PHL causes:	**Subcategory PHL causes:**
1. Cold chain / transport climate control	o Transport modalities (in most cases trucks) are not designed or equipped for the (long-distance) transport of fresh produce o An uninterrupted chain of storages, conditioned rooms for processing, refrigerated transport and product display is generally absent o Absence of pre-cooling affecting quality of produce, or when pre-cooling is available it is used poorly
2. Storage facilities	o Cold storage rooms are insufficient or not available o Performance of storage facilities is poor or suboptimal, due to lack of knowledge on operations and settings, relying on fixed rather than adaptive storage climate settings o Poor monitoring of product quality before entering the storage spoils other produce; faulty climate settings affect quality of stored product
3. Postharvest product handling	o Rough handling of produce in the postharvest chain will cause damages to and quality loss o Absence of grading and sorting in the postharvest chain, or poor application of these will lead to increase of losses o Technology level in postharvest handling is low, and available equipment is outdated, creating inefficiencies
4. Packaging	o Used packaging is not suited for (long term) storage or for (long

		distance) transportation o Use of (traditional) packaging with poor material and no design, causing damages to product during handling, storage & transportation o Overfilling of product packages and wrongly stacking of packages causing bruises, dents, punctures in produce; mixing of products
5.	Infrastructure & connectivity	o Poor quality of roads, particularly in rainy seasons o Public expenditures on infrastructure (roads, rail, energy) is limited, particularly in remote and rural areas o Underdevelopment and unreliability of physical distribution and energy network creates obstructions in the cold chain
6.	Market information / product pricing	o Lack of information on prevailing demand, supply and price of fruits and vegetables and vegetables in various markets o Overflowing of (local) markets with product abundance during peak season causes surpluses in the market and prices to plummet, creating losses of unsold produce o The (local) market does not pay rewards on quality
7.	Education / postharvest R&D	o Workers are untrained or unskilled in operating postharvest technology and/or unaware of postharvest protocols o Low education level leading to inability to adapt new technologies and innovations o Poor or no facilities for postharvest R&D
8.	Processing capacity	o Lack of or inadequate processing facilities causes a shortage of outlets for second and third grade product, leaving produce unused and spoiled o Absence of standards on quality and food safety causing (risk of) cross contamination in processing, and a loss of quality o Processing equipment with low technical efficiency generate high wastes and food losses
9.	Investment capacity / credit access	o Lack of access to capital, collateral (property rights) and high interest rates obstruct investment in postharvest technology o Low investment levels in rural areas due to small-scale production, making it difficult to achieve improvements in efficiency and economies of scale o Low product prices and small revenues create little incentive for small scale farmers to invest in technology to improve production and storage
10.	Standards in quality / quality control	o Produce does not meet quality requirements particularly relevant in produce for export market, leading to product rejections in country of origin or upon destination in export market (e.g. MRL) o Lack of clear standards, or enforcement of these, gives ample room for subjective interpretation and evaluation o Small and medium sized farmers supply a wide variety of quality, creating a mix of good and damaged product
11.	Chain length	o logistic chains and marketing chains of fresh fruits and vegetables are long and complicated, leading to a high degree of distribution risks and loss / lack of information o dominant role of middle men create dependence of producers, low pricing and cutting of producers from the supply chain o Long chain adds to costs and losses, and decreases margins
12.	Available services	o Practical information on postharvest improvements does not reach the producers o Link through extension services between science-based practical research and the sector is absent or insufficient o National extension service programmes have a tendency on focussing on production issues and not on the postharvest chain
13.	Crop protection	o Negligence of pre- and postharvest control of pests and diseases

		affects postharvest product quality and increase of losses in the postharvest chain ○ Losses incurred as a result of vulnerability of fresh product tissue, damages inflicted to produce, absence of effective protection from insects, birds, rodents, weather, etc.
14.	Structure, type of organisation	○ High level of fragmentation and low levels of co-operation in supply chain marketing obstruct economies of scale and efficiency (slow introduction of new technologies) ○ Vast representation of small-scale farmers in the supply of fresh produce, often with limited financial resources, poor access to infrastructure and lack marketing channels for distribution ○ government monopolies in input supply and (export) marketing create little incentive for improvements by private sector farming

The top ten of main categories of PHL causes, ranked by the number of citations is shown in graph 5. The most important causes for PHL are related to the absence of the cold chain in combination with a lack of or poor transport climate control, closely followed by the categories. Weak links in the cold chain or even total absence of a cold chain show that one of the focal points for reducing PHL will have to be improvement of the cold chain and closing of the cold chain. The absence or poor quality of storage facilities in the chain and the improper handling of product throughout the chain have also been cited relatively often, an issue that applies to products other than fruits and vegetables as well, grains in particular.

Graph 4 – Top- 10 ranking main categories PHL causes



The overall impression from the survey of the available literature suggests that developing countries are faced with similar challenges in developing a cold chain infrastructure. The problems of PHL are more or less universal and comparable for all developing countries. This was also confirmed by the interviews with experts and stakeholders from the private sector and knowledge institutes. In more than one case it was remarked by the interviewed stakeholder that it is difficult to link PHL to a specific cause, as in most cases there is more than one cause for PHL and causes are intertwined.

Conceptual design of the Network of Excellence

The Netherlands is one of the world's leading countries in the production, trade and logistics of fresh food products. An important keystone for this position, as well as for securing food and nutrition in the Netherlands in past and present, is the successful network co-operations between agricultural research and education, private sector and government. These alliances or partnerships in innovation in which Dutch knowledge institutes played an important role, is referred to as the 'Golden Triangle' or 'Triple Helix' (Wigboldus, 2011). Co-operation between chain actors in agrologistic performance has been of great value in improving markets and supply chains, and is regarded as a success factor for the competitiveness of the Dutch agricultural complex. In particular in developing economies inefficiencies in supply chains are often caused by shortcomings in agrologistics. By connecting chain actors who have their specific problems regarding losses in their postharvest chain, with parties that have developed a track record with specific knowledge and expertise on agrochain efficiency and performance enhancement, it will be possible to create the opportunity to improve chain performances in these developing economies on a local, regional and global level (Scheer, 2014). The network model of partnerships between different stakeholders can serve as an example on an international level, as a tool to disclose viable knowledge that is available in the Netherlands to parties in developing economies.

The idea of the Network of Excellence (NoE) is to offer a platform for actors in supply chains in developing and emerging countries who have a specific problem or question on postharvest technology, supply chain management or agrologistics, and for parties who may contribute to the development and implementation of an chain improvements. The concept of the NoE is based on the premises that in order to reduce food losses in the postharvest chain it is necessary to apply an integrated or holistic value chain approach that will cover the relevant chain partners. By viewing PHL holistically different fields of expertise will be identified and integrated that combined are necessary to develop a workable and sustainable solution. The mentioned complexity that in many cases is present in the postharvest chain requires cooperation between chain actors and other stakeholders and a combination of expertise in the process, rather than a single issue approach from a single provider.

For reasons that PHL often involve multiple causes for losses, and therefore are complex by their nature, an integrated network approach is necessary, in which:

- PHL will be addressed by means of a demand-driven approach, i.e. the NoE will act upon specific postharvest issue addressed to the network;
- forwarded problems will be reviewed thereby taking all relevant aspects into account, so that a one-sided interpretation approach can be avoided

- the network approach will include an inventory of all stakeholders involved and their respective roles, so that in an early stage of the development process respective responsibilities and interests will be clear;
- fragmented knowledge and expertise will be combined and bundled in one package; and
- transfer of knowledge will be managed as an effort by multiple parties.

The NoE has a key-role in the identification and articulation of the problem or question, thereby addressing the multiple issues that may be involved, and so applying the integrated approach in order to develop a strategy and consortium. The objective will be to develop a network that will serve as an interface for companies and knowledge partners for matching their respective demand and supply of postharvest expertise. As interface the NoE will develop a number of services that are directed towards facilitating of the transfer of knowledge and expertise on postharvest management:

- portal with access to information that will give basic input on postharvest issues;
- tool to acquire information on the specific postharvest issues and so to achieve insight in all elements relevant to determine the appropriate approach;
- support service desk that will provide input on basic postharvest topics;
- quick scan inventory of available postharvest solutions and draw-up outline of investment cases;
- platform for matching of network clients with network members on postharvest issues and expertise required.

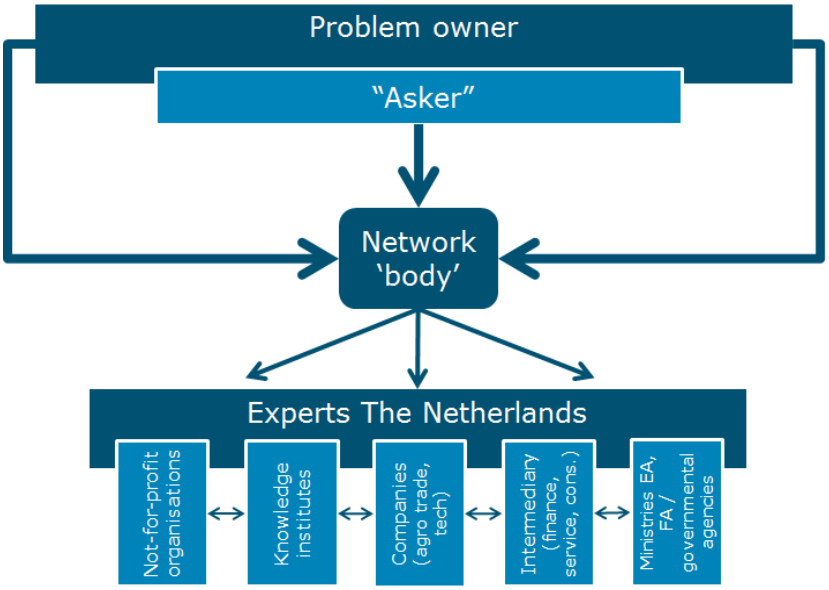
The target group of the NoE is formed by parties in developing and emerging markets who have a direct interest in solving a specific postharvest problem. The primary target group includes producer groups, large-scale farms, traders, logistic service providers, retail and wholesale companies, service providers, etc. Part of the secondary target group are intermediary parties that are involved in or are interested in the development of the sector, but who are not actor in the supply chain itself. This group includes NGOs, local extension and knowledge institutes, embassies, input supplying companies (e.g. seed companies), banks, local ministries, etc.

The Network of Excellence will consist of an inner circle of partners that commit themselves to the network and make available their expertise for the benefit of third parties in developing economies. These partners are referred to as shareholders and will consist of business partners, knowledge institutes, NGOs and ministries or governmental organisations, i.c. parties that commit themselves and are actively involved in developing agrifood chains in developing and emerging economies. Shareholders will also have an important share in the financing of or the sourcing of finance for the NoE's organisation and activities.

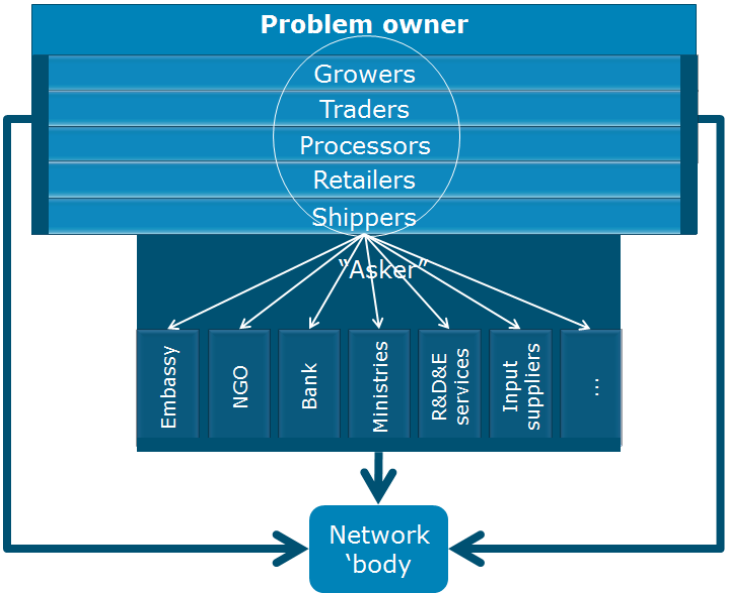
The outer circle of the NoE will include a variety of stakeholders that may have a direct interest in the network's field of operation and activities, and that may participate on a case-by-case basis. These stakeholders are multilateral organizations (e.g. FAO, AU, APEC), international financial institutions (MDBs and MFIs, e.g. AfDB, ADB, IDB, IFC, FMO), other foreign development organizations (e.g. GIZ, SDC, USAID) and foreign sector organizations.

Graphs 6 and 7 present the schematic overview of the NoE showing the pivoting position of the network body, being the interface as described above, with graph 7 showing the primary and secondary target groups in closer detail.

Graph 5 – Network of Excellence, schematic design



Graph 6 – Postharvest 'problem owner' position in the NoE



The NoE will focus on supply chains of perishable food products, specifically fruits, vegetables, roots and tubers. When proven effective the product focus will be extended to other perishables as well, (dairy, meat fish). The activities will be targeted to developing economies, as these countries show a relatively large share of food losses in the upstream activities.

Conclusions

In past decades supply chains for agrifood products, including postharvest systems, have become more complex and will continue to grow more complex as global demand for good quality and safe food will put more pressure on our food systems. The complexity is augmented even further by the necessity to increase the efficiency of resources which includes also the integrated valorisation of food waste streams. Future supply chains will have to be developed in a way that the boundary conditions are determined by the availability of resources and the capability for the optimal valorisation of resources.

Meanwhile several global trends (i.a. increase population, urbanisation, food globalisation, increasing welfare) lead to an increasing strain on the production capacities of food supply chains and on the capability to provide sufficient food quantities at the right place at the right time, safely and at an affordable consumer price. This is particularly the case for food supply chains in developing economies that in general are poorly developed, inefficient, generating high product losses. With food security on top of national and international agenda's, the challenge is to enable a shift in production in such a way that resources (land, water, energy, nutrients) will be used efficiently, and that this production will be sufficient for the growing demand.

It is arguable that actions that will reduce losses in the postharvest chain in developing economies will have positive effects on food security. This applies especially to the supply chains for fruit and vegetables that suffer relatively large food losses up to 50%. In the research a variety of factors were identified that cause losses in the postharvest chain. Whereas PHL can rarely be narrowed down to a single cause, it is quite often the case that these are the result of a combination of interdependent factors.

To reduce losses in the postharvest chain in depth case-by-case analysis is required to develop tailored solutions (one size does not fit for all). By applying a holistic or integrated approach different fields of expertise will be covered and combined; the involvement of and connection between different stakeholders in the process will create the circumstances to set conditions that will increase efficiency and improve performances of fresh supply chains. The issue of impact on food security from measures that are targeted to the reduction of postharvest losses and the quantification of it will, however, have to be substantiated by further empirical research. Analysis and impact assessment

The Network of Excellence Postharvest Losses is initiated as intervention tool for the improvement of performances in postharvest fresh supply chains in developing economies. By linking different stakeholders and expertise the Network wants to provide access to knowledge and expertise to develop strategies to improve postharvest performance. The conceptual design of the network is based on the implementation of an integrated or holistic approach towards agrologistics and postharvest chain development in particular. Stakeholders from the public and private sector, from science and education institutes, and from NGOs form the platform in the network. Being the primary target chain actors from developing economies can address to the Network their specific needs or questions for knowledge and support in postharvest chain matters. As interface the Network's complementary role is to analyse and identify needs and expertise for the development in postharvest supply chains, and to provide the possibility to connect or match with providers of postharvest expertise. Ultimately the purpose of the Network of Excellence Postharvest Losses is to contribute to the elimination of postharvest losses in supply chains for perishable products.

References

AUC-FAO (2012) "Management of postharvest systems in sub-Saharan Africa in 21st century". Presentation at the AUC/FAO High Level Forum 'Support to regional capacity building to reduce postharvest losses in sub-Saharan Africa. Addis Ababa 17-18 October 2012, Ethiopia.

Collins, R. (2009) "Value chain management and postharvest handling: partners in competitiveness". From: Postharvest handling: A Systems Approach. Eds.: (eds.) Wojciech J. et al., p.107-127. Elsevier Inc., New York USA

Dobbs, R., Oppenheim, J., Thompson, F.. Brinkman,M., and Zornes, M. (2011) "Resource Revolution: Meeting the world's energy, materials, food and water needs". McKinsey Global Institute, London, United Kingdom.

Escaler, M. and Teng, P. (2011) "Mind the Gap: Reducing waste and losses in the food supply chain". NTS Insight June. RSIS Centre for Non-Traditional Security (NTS) Studies, Singapore.

FAO (2011) "Food loss reduction strategy". Food & Agriculture Organisation of the United Nations, Rome, Italy.

FAO (2012) "High and Volatile Food Prices - FAO support to country level contingency planning". Food & Agriculture Organisation of the United Nations, Rome, Italy.

FAO (2013) "The state of food insecurity in the world 2013: The multiple dimensions of food security". Food & Agriculture Organisation of the United Nations, Rome, Italy.

Gordon, A. and Woodhill, J. (2012) "Raising the bar: what is global food and agri-business saying about their sustainability goals?" Wageningen UR Centre for Development Innovation, Wageningen, the Netherlands.

Gustavsson, J., Cederberg, C., Sonesson, U., Otterdijk, R. and Meybeck, A. (2011) "Global food losses and food waste: extent, causes and prevention". Food and Agricultural Organization of the United Nations, Rome, Italy

High-level Expert Forum (2009). How to feed the world in 2050 – global agriculture towards 2050. FAO, Rome Italy.

HLPE (High Level Panel of Experts) (2014) "Food losses and waste in the context of sustainable food systems – collection of contributions received", HLPE consultation on the V0 draft of the report. Global Forum on Food Security and Nutrition, FAO, Rome, Italy.

Hodges, R. J. and M. Bernard (2010). "African Postharvest Losses Information System–a network for the estimation of cereal weight losses." Julius-Kühn-Archiv 245(Proceedings of the 10th International Working Conference on Stored Product Protection): 956-962.

Kaplinsky, R. and Morris, M. (2001) "A handbook for value chain research". Institute of Development Studies, University of Sussex, Brighton, United Kingdom.

Kitinoja, L., Saran, S., Roy S.K., and Kader, A. (2011) "postharvest technology for developing countries: challenges and opportunities in research, outreach and advocacy". J. Sci. Food Agric., 91: 597–603. doi: 10.1002/jsfa.4295.

M4P (2008) "Making value chains work better for the poor: a toolbook for practicioners of vaue chain analysis, version 3". Making Markets Work Better for the Poor (M4P) project. Department for International Development (DFID), London, United Kingdom.

Mrema, G.C. (2012) "Policies and institutional frameworks for reducing post harvest losses in SSA". Presentation at the AUC/FAO High Level Forum 'Support to regional capacity

building to reduce post-harvest losses in sub-Saharan Africa. Addis Ababa 17-18 October 2012, Ethiopia.
Parfitt, J. & Barthel, M. (2011) "Food waste reduction: a global imperative". Resource Futures / WRAP, Bristol, UK.
Parfitt, J., M. Barthel and S. Macnaughton (2010) "Food waste within food supply chains: quantification and potential for change to 2050". Philosophical Transactions of the Royal Society – Biological Sciences: 3065-3081, UK.
Rabobank (2011) "Rethinking the F&A Supply Chain – impact of Agricultural Price Volatility on Sourcing Strategies". Rabobank International, Utrecht, Netherlands.
Scheer, F.P, Gogh, B., Ravensbergen, P., Burgh, M. van der, Westra, E., Waarts, Y., Rutten, M. Aramyan, L. (2014) "Visie internationale agrologistiek; inventarisatie naoogst verliezen en verbeterde voedselzekerheid in opkomende landen en de mogelijke bijdrage van het Nederlandse bedrijfsleven". FBR report 1430 Wageningen University & Research Centre, Wageningen, the Netherlands.
United Nations (1987) "Our Common Future". Report of the World Commission on Environment and Development (Brundtland Commission). United Nations Organisation, Washington D.C., USA.
Van der Vorst, J.G.A.J. (2000) "Effective food supply chains; generating, modelling and evaluation supply chain scenarios". Wageningen University and Research Centre.
Van der Vorst, J.G.A.J. and Snels, J. (2014) "Developments and needs for sustainable agro-Logistics in developing countries". Multi-Donor trust Fund for Sustainable Logistics (MDTF-SL), World Bank Position Note, January 2014, Washington D.C., USA.
Van Gogh, B., Aramyan, L., Sluis, A. van der, Soethoudt, H., Scheer, F.P. (2013) "Feasibility of network of excellence postharvest food losses; combining knowledge and competences to reduce food losses in developing and emerging economies". FBR report 1402 Wageningen University & Research Centre, Wageningen, the Netherlands.
Wigboldus, S.A. & Lee, J. van der (2011) "Going for gold in innovation partnerships to food insecurity – the role of knowledge institutes". Volume 1: context study. Wageningen UR Centre for Development Innovation, Wageningen, the Netherlands.
Zuurbier, P.J.P., Trienekens, (J.H.) and Ziggers, G.W. (1996) "Vertical samenwerking". Kluwer Bedrijfswetenschappen, Deventer, The Netherlands. (Dutch publication)

Bio / profile

Wageningen University and Research Centre (also known as Wageningen UR and sometimes abbreviated to WUR) is a research and higher education concern which consists of Wageningen University and the former agricultural research institutes (Dienst Landbouwkundig Onderzoek) from the Dutch Ministry of Agriculture Nature and Fishery. Food & Biobased Research is part of Wageningen UR and develops sustainable, innovative and market oriented solutions for healthy food, fresh food chains, biorefinery, biobased chemicals and materials. LEI Wageningen UR is a leading social-economic research institute in international terms and an independent, strategic partner for government and companies.

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