

Good Agricultural Practices for greenhouse vegetable production in the South East European countries

Principles for sustainable intensification of smallholder farms

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9. Profitability, marketing, and vegetable loss and waste

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ABSTRACT

Enhancing vegetable profitability implies cultivation of standardized high quality produce, implementation of advanced technologies for competitive production and optimization of resources. Small stakeholder farms require innovative strategies to enter new markets and extend the impact of local and niche productions, while achieving sustainability. Food wastage accounts for one-third of world food production; it occurs to varying degrees at all stages of the food supply chain. More than 60% of the total wastage of fruit, vegetables, roots, tubers and bulbs takes place during harvesting and consumption. To reduce food wastage in the food supply chain – by recycling and re-using plant residues, among other approaches – is both smart and sustainable. This chapter outlines production and marketing strategies that can be adopted by small stakeholder farmers in SEE countries to increase profitability. It illustrates in detail practices to minimize losses in protected cultivation systems and to reduce losses and waste during post-harvest and throughout the food supply chain. Recommendations are presented on produce handling in order to achieve sustainable added value.

Key questions

- What is the difference between food loss, food waste and food wastage?
- How do you increase profitability by reducing waste?
- What are important considerations for avoiding production losses?
- Why should promiscuity between horticultural and livestock farms be avoided?
- What are the recommended measures at harvest?
- How can the temperature of vegetables be rapidly reduced after harvest?
- What protection devices and services should the employer provide for employees?
- How often should you check the quality of the water along the food supply chain?

PROFITABILITY AND MARKETING

Agricultural and post-harvest innovations have led to a continuous increase in yield and productivity. Nevertheless, there is still not enough food for everyone. To meet the needs of the growing global population within sustainable limits, it is necessary to make the food supply chain more efficient, while protecting natural resources and effectively managing ecosystems. It is vital to:

- increase productivity;
- minimize production of wastage; and
- maximize re-use of wastage.

Small stakeholder farms in SEE countries can sustainably intensify production by adapting growing systems and improving the management of raw material. Protected cultivation is under continuous expansion: greenhouses are suited to soilless cultural systems and the farmer is able to control inputs. Moreover, soilless cultural systems – the most intensive production systems in today’s horticulture industries – are ideal for standardizing production and enhancing yield, resulting in healthy and sustainable foods that satisfy market requirements (Nicola *et al.*, 2007; Gruda, 2009).¹

Thanks to innovation and new technologies in the horticultural sector, there are an increasing range of new products and fresh convenience foods. For example, leafy vegetables are not only available as whole-head and multi-leaf vegetables,² but also as “baby” leaves, which are increasingly used in salad mixes. Protected cultivation vegetable farmers in SEE countries could increase profitability by producing baby leaf vegetables: cost effective to grow, easy and fast to process (Martínez-Sánchez *et al.*, 2012). Furthermore, baby leaf vegetables would allow farmers access to new markets, especially if supported by an efficient food supply chain. Indeed, despite the economic crisis in recent years, consumers have not necessarily reduced their consumption of vegetables, but they have changed how they consume them (Heaton and Jones, 2008).

Another rapidly expanding sector of interest to growers, processors, retailers and consumers is **fresh-cut vegetables**, characterized by convenience, freshness and health benefits. These vegetables represent an opportunity for small stakeholder farms in SEE countries, who could offer a wide range of species and varieties/cultivars, together with additional services, such as minimum processing (e.g. husking, cutting, packaging), particularly for vegetables sold independently by large-scale retailers.

¹ See Part II, Chapter 7.

² See Part III, Chapter 5.

Profitability could be further enhanced by organizing the supply of raw materials based on the demands of customers and taking account of each smallholder's strengths. For example, one crop may be more suited to a large enterprise (e.g. tomato, pepper, strawberry), while another crop may be better suited to a smaller farm (e.g. leafy vegetables). The classification of raw material allows farmers to produce added value and sell vegetables at different prices, avoiding economic flattening.

Marketing the product offers many opportunities for increased profitability:

- identification of new markets and sales channels, including large-scale retail trade;
- organization in cooperatives to agglomerate and concentrate the vegetable production of a number of smallholdings;
- production of niche products, traditional or native varieties to create added value appreciated by consumers; and
- establishment of trademarks, certifications or labels to encourage consumption.

Certification systems distinguish vegetable products based on specific characteristics, qualities or reputations. A product may be differentiated by its geographical origin, history or distinctive character related to natural or human factors, such as soil, climate, local know-how and traditions. Certification (such as the IGP label in Italy, which guarantees the origin of food produced in specific areas, e.g. Pachino tomatoes cultivated in a specific area of Sicily) can increase profitability. It has additional advantages, allowing farmers to:

- contribute to rural development;
- preserve local resources;
- maintain traditions;
- increase food diversity and offer a wider choice to consumers; and
- prevent delocalization and rural exodus.

Labelling is an important commercial tool which could be exploited by small stakeholder farmers in SEE countries. Vegetable marketing and labelling in Europe is regulated by EU Regulation No. 543/2011, which includes detailed rules for the application of Council Regulation (EC) No. 1234/2007 with regard to fresh and processed fruit and vegetables. Farmers may also opt for voluntary private labelling – a potentially effective marketing strategy, as consumers are increasingly aware of the importance of vegetable quality and interested in a product's origins. Tailored stickers can be created with the name of the farm, logo, production area and any other information which personalizes the product and makes it easily recognizable. In order to reach new markets and take advantage of global tourism, information could also be made available in English.

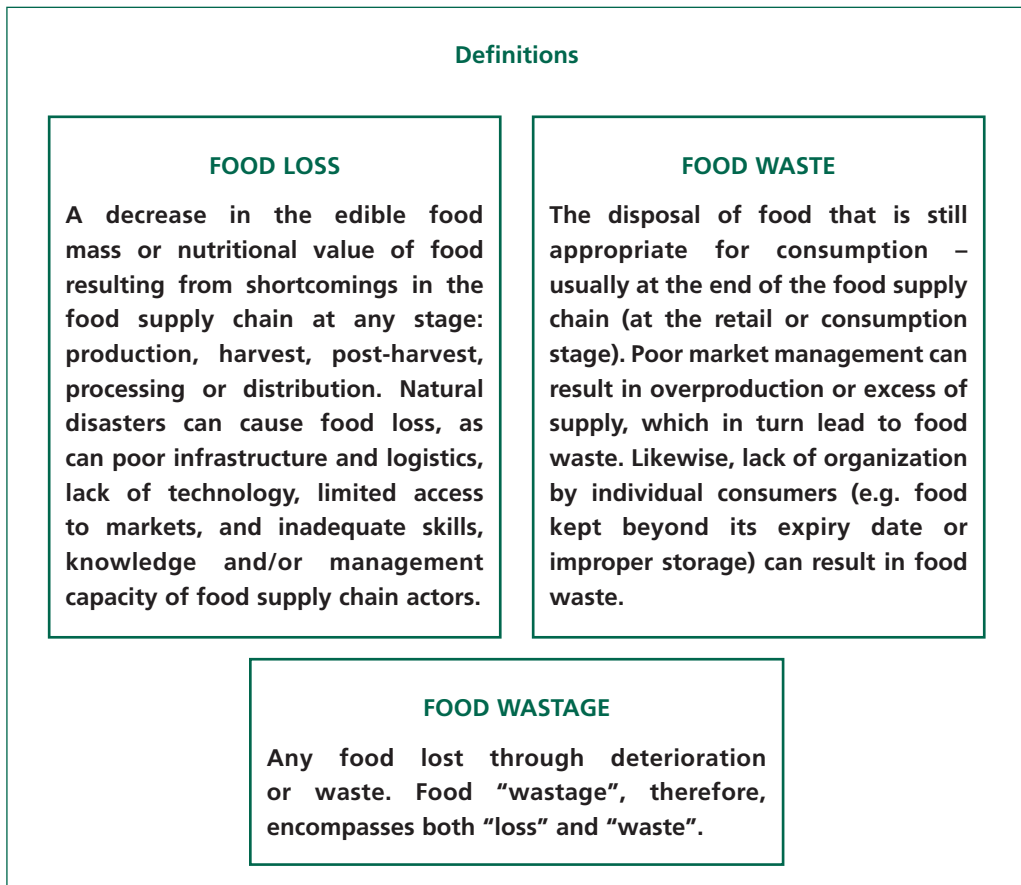
Labelling not only guarantees fair trading and free movement of foodstuffs, and provides the consumer with accurate information about the product, but it can also be used as a marketing tool to promote the product and expand the market.

Other strategies may be adopted, depending on the local context, to attract consumers. For example, e-commerce combines accessibility with convenience, allowing the customer to choose products according to seasonal availability or on the basis of specific offers and promotions on the farm's Web site. The commercial side could be supported by a home delivery service (see "box schemes" below). Another strategy is to promote the hedonistic aspect, arousing human curiosity and encouraging contact with nature, for example, with direct sale at local markets, fairs and festivals or on the farm itself ("farmer markets"). Direct sale on the farm may also be combined with teaching or gastronomic tours to raise consumer awareness and give an insight into agricultural reality. Both e-commerce and direct sale could be further boosted by offering additional services, such as traditional recipes or tips for home storage, to create a satisfied and loyal customer base (e.g. the AMAP – Association for the Maintenance of Family Farming – system in France).

The direct involvement of consumers in the local community – through, for example, box schemes, solidarity purchase groups (GAS, in Italy) and community supported agriculture (CSA) systems – shortens the food supply chain.

- In **box schemes**, the customer signs up for a box of locally produced fruit and vegetables to be delivered directly to their home or to a collection point; alternatively, the scheme may be organized as a cooperative. Delivery is typically weekly or fortnightly.
- **Solidarity purchase groups** are promoted and organized by consumers, formally or informally, to share the purchase of goods, generally agricultural products. Such groups can benefit farmers and farmer associations, as well as the local community.
- **Community supported agriculture** allows individuals/consumers to support farm operations and activities through a "sharing economy". In CSA, individuals become "shareholders" of the farm, contributing in advance to the farm operation costs and farmer's salary and receiving a share of the revenue. CSA is a participatory economy, with growers and consumers providing mutual support and sharing the risks and benefits of food production. Consumers support the system that provides quality products at better prices, while growers gain financial security and are relieved of the burden of a marketing strategy.

The above schemes all shorten the food supply chain, which in turn results in competitive prices, allowing farmers to maintain the value chain. There is also a lower risk of unsold produce and a marked reduction in food wastage.



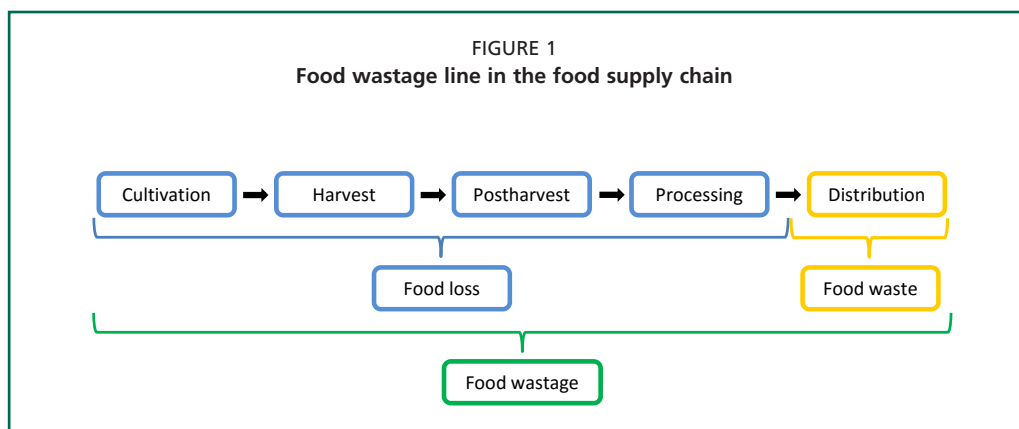
FOOD SUPPLY CHAIN WASTAGE

Food loss, waste and wastage refer to human edible material that is discarded, lost, degraded or consumed by pests at any point in the food supply chain. Food originally destined for human consumption but then redirected from the food supply chain to a non-food use – for example, as animal feed or in by-product industries – is also considered food loss, waste or wastage (Figure 1) (Parfitt *et al.*, 2010).

Food production and food wastage

According to FAO, vegetable production in Europe accounts for approximately 7% (0.07 billion tonnes) of world production.³ Total food wastage accounts for around one-third of total food production for human consumption. Wastage occurs throughout the food supply chain to varying degrees, depending also on the location. It is as high in more industrialized countries as it is in less

³ See Part I, Chapter 2.



industrialized countries, but occurs at different stages of the supply chain. The more industrialized a country is, the higher the percentage of waste after distribution (at retail and consumer level) – i.e. there is more waste than loss. In contrast, in less industrialized countries, the majority of waste occurs during harvest and post-harvest – i.e. there is more loss than waste (FAO, 2011a).

Of the global production of fruit, vegetables, roots, tubers and bulbs, food waste is 40–50%, depending on the product and season (FAO, 2011a, 2011b; Venkat, 2012). In Europe, food waste in fruit and vegetable production is about 46% and occurs throughout the food supply chain (Plate 1). For root and tuber production in Europe, food waste is even higher, accounting for over half the production (FAO, 2011a).

Added value and prevention of food waste

Food waste involves not only wastage of input and agricultural land area, but also missed opportunities. According to the European Commission, the global waste market from collection to recycling is worth an estimated €400 billion every year; this represents significant potential in terms of the creation of jobs. A well-organized waste industry, encompassing smart and sustainable activities, could permit countries to retain or create wealth and avoid disposal costs.⁴

Smallholder farms could implement a range of sustainable activities:

- Apply crop residues to the soil to improve the balance of the soil organic matter and for better weed control (some Brassicaceae species are particularly suited, given their high biomass).
- Recycle plant waste to exploit the extraction of bioactive compounds (tomato skin and seeds can provide polysaccharides and phytochemicals for use in the dietary supplement and cosmetic industries).

⁴ For extensive coverage of the waste market economy, see the chapter on “Waste” in the *Green Economy Report* of the United Nations Environment Programme (UNEP, 2011).



Plate 1

Food waste at the wholesale market



- Collect discarded unmarketable produce (whether whole or only the outer parts; damaged during production, transport or storage) for use as:
 - fertilizer, mulch or compost (Plate 2); or
 - feed for farmyard animals.
- Redirect material towards bioenergy (research is underway to valorize tomato crop residues for bioenergy production in the form of pellets).
- Exploit opportunities to use damaged or discharged raw material to obtain biodegradable containers or packaging material.

The above activities could be carried out on the farm or – when specific skills or equipment are required – by specialized companies. There are significant employment opportunities at food wastage collection and during transformation in the various industrial sectors.

A systemic approach to innovative wastage prevention and management has potential benefits both for society in general and in terms of farmers' profitability. There are many advantages, including:

- reduced impact of food loss and food waste (in terms of quantity and cost);
- increased income for smallholder farms;
- creation of sustainable value chains in the farming and processing sectors as a result of the efficient use of agricultural waste, co-products and by-products; and
- reduced impact on the environment, as a result of the adoption of sustainable extraction rates and optimal use of resources for soil improvement.



Plate 2

Crop residues to be wasted if not recovered

REDUCING WASTAGE AND INCREASING PROFITABILITY

To enhance the profitability of SEE vegetable small stakeholder farms, it is necessary to achieve standardized high-quality production while optimizing the resources. Vegetable quality and shelf-life are affected by pre-harvest, harvest and post-harvest conditions; consequently, to achieve profitability and competitiveness, action is required at the various stages of the food supply chain, including processing, storage, transport and distribution.

Vegetable production issues are global with variations at local, regional, national and international level. SEE vegetable farms – and farms worldwide – vary enormously, depending on, *inter alia*, the technological inputs available, infrastructure facilities, cultural systems, species grown, knowledge, business organization and management, and sales channels. There is no simple solution to reduce overall quality deterioration of fresh products. However, maintaining high hygienic standards reduces both microbial proliferation and physical pollution, resulting in reduced food loss and food waste and extended shelf-life.

Factors affecting vegetable quality and shelf-life

Pre-harvest

- Seed and cultivar choice
- Climate, environmental, soil/growing media and nutrient management and knowledge
- Water usage
- Standardization of cultural system
- Sowing and transplanting scheduling
- Agricultural practices and crop protection (e.g. soil amendments, fertilizers, pesticides, fumigants, growth regulators)

Harvest

- Timing
- Conditions and practices
- Standardization of raw material management

Post-harvest

- Best processing practices⁵
- Raw material manipulation (e.g. packaging)
- Storage conditions
- Transportation, distribution and sale

**Vegetable quality
and shelf-life are
affected by pre-
harvest, harvest
and post-harvest
conditions**

⁵ Conditions after harvest can be modified with the objective of extending shelf-life and increasing the content of dietary phytochemicals, such as vitamin C, phenolic compounds and carotenoids, adopting techniques such as pulsed light or thermal shocks.

The adoption of **international production practices and protocols** for the main commodities brings many benefits:

- Improved access to raw material with specific characteristics.
- Satisfaction of consumer demand.
- Creation of new demand.
- Respect for food safety limits, with the promotion of standardized vegetables with specific qualitative and commercial properties.
- Internationally recognized certification, meeting customer needs and expectations.

Tailored actions and solutions are necessary to increase efficiency, reducing food loss and food waste

Nevertheless, to increase SEE small stakeholder farm productivity, improve competitiveness through standardization and enhance efficiency – and thus profitability – custom-made solutions are required. Good agricultural practices are not to be adopted blindly, rather carefully fitted, developed and adapted to enable small stakeholder farms to fit seamlessly into the production flow.⁶

Food loss

Actions to reduce food loss focus on preventing mismanagement at farm level. Poor management affects productivity (both directly and indirectly), as well as the post-harvest and processing stages.

Cultivation

To reduce food loss and input waste, it is necessary to plan and monitor every step of the growing cycle:

- **Variety/cultivar selection** should take account of characteristics (e.g. response to sowing or planting, disease, stress and pest resistance, edaphic and climatic adaptability, response to fertilizers and agrochemicals), and when possible combine with high yield potential in a short growing cycle (Plate 3). Produce should satisfy the needs of the food supply chain,



Plate 3

Radicchio variety enhancement for reduced residue production: old variety with high percentage of non-edible head (top) and recent variety with reduced non-edible amount (bottom)

⁶ For more information on productions indications, practices, protocols and production disciplinarys, see “Useful links for vegetable quality” in the Bibliography on p. 263.

taking into consideration both the fresh market and the processing industry. Therefore, while storage resistance is an important characteristic, it is also important to seek processing opportunities to avoid unsold production.

- **Nursery management** is often neglected, particularly by smallholders, who do not adopt best practices. Nurseries should be located far from the production area to reduce the risk of pollution; seeds must be stored correctly. When external nurseries are used as contractors (a common practice), the transportation of transplants should be managed carefully.⁷
- **Scheduling** of agronomic activities can affect profitability and marketing and reduce post-harvest loss and waste. Sowing and transplanting should be timed separately for each commodity and speciality, taking into account the growing cycle, to avoid the maturation of all crops simultaneously. With planned scheduling, it is possible to:
 - avoid harvest overlaps resulting in huge amounts of raw material to be harvested and sold in few days;
 - optimize logistics and storage facilities;
 - control raw material quality;
 - facilitate traceability;
 - separate and store raw material in batches/lots;
 - optimize profitability, without having to propose special offers or discounts to sell in bulk;
 - avoid market saturation and consequent price reductions; and
 - reduce the possibility of being left with unsold raw material.
- **Cultural practices** have a major impact on profitability. When horticultural and livestock production overlap, there may be cross contamination. In protected cultivation using traditional soil cultural systems, knowledge of the site and of the history of the surrounding area is important to assess and manage risk adequately. For example, it is possible to avoid the cultivation of vegetables in soil previously used for animal production or chemical/biological waste disposal or once covered by polluted surface water. There is an increasing awareness of the potential harm caused by solid biological waste, water runoff and chemical usage. Correct manure management, the use of alternatives to chemicals (e.g. mulching) and the adoption of paved floors can all reduce the impact (Plate 4). The adoption of open or closed soilless cultural systems could avoid runoff and leaching of nutrients into the surface or the groundwater. During cultivation, bad practices, such as the improper disposal of pruning residues, can cause the spread of diseases resulting in food loss (Plate 5). Moreover, failure to achieve quality standard requirements can also cause food losses due to unsold production (Plate 6).

⁷ See Part II, Chapter 6.



NICOLA



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Plate 4

Improper storage location for manure causing leaking: on roads between lots (left) and in fields and greenhouses (right)



NICOLA



NICOLA

Plate 5

Improper management of pruning residues

Plate 6

Food waste due to commercial requirements

GAP recommendations – Pre-harvest

- Conduct soil analysis.
- Use selected varieties/cultivars and grafted plants.
- Store seeds in a closed container in a dark refrigerated room.
- Promote practices that enhance soil productivity without compromising hygiene, depending on the cultural system used and the species cultivated (see Practical example a, p. 264).
- Apply recommended plant densities for each species and plan a balanced and constant supply of nutrients (see Practical example b, p. 264).
- Use registered materials for crop protection with short pre-harvest intervals, following label indications.
- Regulate the temperature, relative humidity and irrigation (dosage and timing) according to the growing systems and the species.

GAP recommendations – Harvest

- Remove damaged outer parts of the raw material to avoid fermentation or browning.
- Reduce rapidly the temperature of both the vegetables and the environment.
- Optimize timing in the field to coordinate with the shipping procedure to reduce raw material overheating and physical damage.

Harvest

Harvesting is a crucial stage in the food supply chain, with potentially high food losses due to improper preparation and handling. Most SEE small stakeholder farms are not equipped with rapid cooling systems to prevent an increase in temperature and respiration of harvested raw material. The only solution is to harvest early in the morning. While many farmers carry out the harvest using automated and mechanized systems, hand-picking has the advantages of reducing physical injury, preventing direct contact with the soil and selecting for quality.

Post-harvest

Raw material quality cannot increase after harvest; it can at best be maintained and preserved through the food supply chain.⁸ It is important to avoid conditions that could cause physical damage, wilting and softening, and the subsequent increase in respiration, fermentation and browning. These negative effects are the result of:

- inappropriate handling;
- absence of rapid pre-cooling systems in the field and during transportation to the packing house;
- excessive delay in the field, coupled with poor coordination with the subsequent food supply chain steps; and
- transport on bumpy roads.

Transportation and storage are critical stages. To avoid food loss, it is important to separate the raw material, maintain a high level of cleanliness, and monitor carefully the temperature, controlled atmosphere, relative humidity and dark conditions according to the specific requirements of each commodity (Plate 7).

To reduce the risk of food wastage during processing, transportation and storage, it is also necessary to consider the respiration rate of the raw material and its sensitivity to temperature and to ethylene. Post-harvest temperature sensitivity varies depending on the commodity, and it can affect respiration intensity (Tables 1, 2). Chilling-sensitive commodities are bean, snap, cranberry, cucumber, eggplant, muskmelon, pepper, potato, pumpkin, squash, sweet potato, tomato, watermelon and yam. Horticultural products can synthesize ethylene and their sensitivity varies (Table 3). Producers should know the tolerance limit

⁸ However, it is possible to increase the content of ascorbate and other dietary phytochemicals.



Plate 7 (From left to right and top to bottom)
 Truck with ice for transport from field to storage
 Body icing in closed box storage for rapid raw material cooling
 Closed and shaded truck for transport from harvesting area to storage
 Hydrocooling system in transport truck on arrival at packing house
 Top icing in closed insulated box storage for cold preservation of raw material before dispatching
 Storage room at cold temperature on a small farm in Croatia

of each vegetable in order to properly schedule and manage the raw material. It is important to avoid mixtures and promiscuity, which might accelerate inner degradative physiological pathways. Failure to maintain optimal conditions or to properly manage raw material can cancel the positive effects of the previous steps in the supply chain, thus reducing the shelf-life.

GAP recommendations – Post-harvest

- Handle raw material in a refrigerated, clean and insulated room.
- Ship and store raw material in a clean environment under optimal conditions:
 - temperature 1–4 °C;
 - controlled atmosphere (relative humidity > 90%); and
 - darkness (or as close as possible).
- Check conditions routinely.

TABLE 1
Recommended transportation and storage temperature of vegetables

Temperature range °C	Commodities
0–5	Artichoke, broccoli, Brussels sprouts, cabbage, cauliflower, celeriac, celery, chervil, Chinese cabbage, chives, coriander, dill, leeks, lettuce, mushroom, onions, onions (bunching), parsley, radish, spinach, sorrel, watercress, witloof chicory
0–10	Sugar peas
1–5	Asparagus, cucumber (pickling)
2–7	Cantaloupe
5–10	Bean
5–12	Pepper bell, pepper chilli
8–12	Cucumber, okra
10–20	Tomato

Watkins and Nock, 2012 (adapted).

TABLE 2
Vegetable commodities classified in function of the respiration rate

Classification	mg CO ₂ /kg·h at 5 °C	Commodities
Very low	< 5	Dried vegetables
Low	5–10	Beet, celery, garlic, honeydew melon, onion, potato (mature), sweet potato, watermelon
Moderate	10–20	Cabbage, cantaloupe, carrot, celeriac, cucumber, lettuce (head), pepper, potato (immature), radish, summer squash, tomato
High	20–40	Carrot (with tops), cauliflower, leeks, lettuce (leaf), lima bean, radish (with tops)
Very high	40–60	Artichoke, bean sprouts, broccoli, Brussels sprouts, endive, green onions, kale, okra, snap bean, watercress
Extremely high	> 60	Asparagus, mushroom, parsley, peas, spinach

Watkins and Nock, 2012 (adapted).

TABLE 3
Vegetable commodities classified in function of the ethylene synthesis rate

Classification	µl C ₂ H ₄ /kg·h at 20 °C	Commodities
Very low	< 0.1	Artichoke, asparagus, cauliflower, leafy vegetables, root vegetables, potato
Low	0.1–1.0	Casaba melon, cucumber, eggplant, okra, pepper (sweet and chilli), pumpkin, watermelon
Moderate	1.0–10.0	Honeydew melon, tomato
High	10.0–100.0	Cantaloupe

Watkins and Nock, 2012 (adapted).

Processing

To avoid food loss during processing, it is important to apply rigorous standards of hygiene and ensure the water quality to avoid physical, chemical and microbiological contamination. Such standards apply to the physical structures, the workers and all equipment and instruments used.

Food waste

Food waste can occur both for niche speciality products with a limited scale of sale and for widespread commodities marketed over long distances. Small stakeholder farmers selling produce directly (farm shop, street and wholesale markets) or processing it individually may produce food waste for the reasons described above with regard to food loss. Farmers not marketing produce directly or processing vegetables individually must create a direct and quick communication channel with processors and/or distributors in order to preserve the vegetables (Plate 8). In both cases, storage for an excessively long period can lead to waste.



NICOLA



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NICOLA



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Plate 8 (from left to right and top to bottom)
Fresh produce on sale in improper, dirty and wet containers, located under the rain
Produce transported and left under the sun on a street market
Produce at wholesale market without any refrigeration system or insulation, stacked in large quantities possibly resulting in mass overheating
Improper handling on the wholesale market, fresh produce stored in non-insulated or refrigerated transport unit using newspaper and plastic bags with buildup of product temperature

Production environment

Water quality and management

It is essential to know the location of the water source and the history of the area in order to assess and manage risk adequately. There can be unforeseen variations in the chemical characteristics and level of contamination of the water used for irrigation and during post-harvest activities. The water supply needs to be monitored so that at each step in the food supply chain producers know the pH, conductivity and salinity, as well as the level of microbial, heavy metal and chemical contamination. Water is one of the main vehicles of contamination; if monitored accurately, it is possible to use sanitizers during cultivation (especially when using overhead irrigation systems) and during post-harvest washing procedures (Plate 9). It is imperative to protect and manage the water supply through:

- collaboration with neighbours to reduce sources of contamination using a vegetative buffer zone;
- protection of well openings;
- implementation of measures to avoid cross-contamination;
- selection of an appropriate water source;
- adoption of good water storage practices; and
- application of water dosage to avoid excess irrigation causing damage to the raw material (e.g. cracking, increased susceptibility to physical damage, delayed maturity and reduced soluble solids content).⁹



Plate 9

Rapid washing after harvest to remove foreign bodies and dirt, while preserving commercial quality

Physical, chemical and microbiological contamination

Contamination can occur at any stage in the food supply chain. Contamination places the hygienic and commercial value of the produce at risk, which in turn causes food loss and food waste. Small stakeholder farmers and post-harvest workers should identify potential sources of contamination, and implement practices to reduce or eliminate them. Possible **sources** of contamination include:

⁹ See Part II, Chapter 3.

- roads and the wheels of vehicles and machines (Plate 10, left);
- passageways and floors throughout the premises, as well as shoes (Plate 10, right);
- uncleaned stacked pallets and racks;
- containers and forklifts;
- ducts, fans and crevices;
- courtyard animals, pets, birds (and their fecal matter) – attracted by potential food sources and habitats – a situation exacerbated by the absence of a revolving door/double door/anteroom;
- mosquito nets/screens; and
- insect and rodent traps.



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Plate 10

*Pit with water and sanitizer to sanitize truck tyres when entering and exiting the premises (left)
Pad with sanitizer to sanitize workers' shoes at the entrance of the premises of a company in Croatia (right)*



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Plate 11

*Double doors at the entrance and protected corridors between units (left)
Forced airflow at the entrance to prevent insect entrance (centre)
Door separating packing premises from cultivation area (right)*

Inappropriate **practices** can also result in contamination, for example:

- absence of protection for light bulbs and glass;
- proximity between stored raw material and non-food substances; and
- poor cleaning practices (e.g. use of unsuitable cleanser prior to sanitization, incomplete removal of detergent from equipment, incorrect water temperature, wrong sanitizer concentration and re-use of rinsing water).

Workers, instruments, monitoring

Health and safety are often undervalued in the food supply chain. Employees at all levels should receive appropriate training to improve awareness of the potential risks derived from:

- poor personal hygiene;
- failure to recognize disease symptoms;
- lack of respect for regulations and safety signs;
- bad practices (e.g. eating, drinking or smoking in the working area);
- inappropriate dress (e.g. wearing jewellery); and
- misuse or non-use of personal protection devices (e.g. masks and gloves) (Plate 12).

Equipment, tools and conveyances do not always receive the necessary attention, particularly in small stakeholder farms. Cross-contamination and risk of pollution/proliferation may occur when plastic containers, wooden equipment, tools and conveyances are not properly repaired, visually inspected, cleaned, washed, sanitized, rinsed and stored. Similarly, poorly maintained crawlspaces and corridors for the passage of both employees and conveyances at the entrance and exit can result in food wastage.

Fast and simple **measurement instruments**, such as the chlorophyll meter, N tester, colorimeter, penetrometer and refractometer, are useful to control the



Plate 12

Sanitary units in place, strawberry tunnels, Croatia (left)

Safety precautions for visitors, tomato glasshouse, Croatia (centre)

Sanitation room for workers prior to entering post-harvest handling and processing premises (right)

maturation process and/or define the best harvesting time. These instruments can also be used to control and sort raw material according to quality prior to sale to wholesalers, enabling the delivery of products of high quality and with commercial added value.

Technical devices – sensors, diagnostic tools and data loggers – are necessary to check and measure growing and environmental conditions in the food supply chain. These devices can be used to obtain data on the temperature, relative humidity and atmosphere, and a timer and logic module can then be used to regulate/activate schedules and the water- and airflows.

Traceability is essential in order to track all the activities in the food supply chain. On small stakeholder farms, the harvested raw material should be divided and stored in batches/lots until the end of its shelf-life. It is important to record all cultivation and post-harvest activities and to keep the relative documentation for a set period (months or years) (Plate 13).



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Plate 13

Samples of lots sorted for tracing purposes for fresh produce (left) and fresh-cut produce (right)

CONCLUSIONS

The measures implemented by each small stakeholder farmer in SEE countries depend on the size of the farm and the resources available. The suggested steps to increase profitability and reduce both food loss and food waste may be too complex and too expensive for consideration by some small stakeholder farmers. Priorities can vary, depending on the type of product and the cultural system. Consequently, a step-by-step approach is required, focusing on those factors that impact most on the protected cultivation system. It is imperative that farmers are open to new ideas, such as the development of a joint implementation strategy involving all beneficiaries. It is useful to establish a system to monitor and record performance, activities and achievement of objectives.

GAP recommendations – Along the supply chain

- Perform routine analysis on the water used for irrigation and during post-harvest (see Practical example c – in the box below).
- Implement actions to protect and properly manage the water source.
- Schedule periodic inspection of facilities to identify outbreaks and/or contamination.
- Avoid promiscuity and keep working tools and facilities clean.
- Separate equipment, tools and conveyances according to their function.
- Provide training to all employees on safety, technical knowledge and emergency action procedures.
- Provide employees with sufficient locker room space and with toilets or sanitary mobile units (located at an appropriate distance from the working area).
- Allocate a place for filing and checking all documentation required for traceability.
- As applicable, apply automated/mechanized practices and organize flows and communications in the food supply chain (see Practical example d – in the box below).
- Check for accuracy: calibrate measuring instruments prior to use and level all scales and balances.

Practical examples for small stakeholder farmers

- a) Incorporate raw manure into the soil at least 2 weeks prior to planting, but avoid with commodities that are harvested within 120 days. Apply organic fertilizer in pre-planting or in the early stages of plant growth near the roots and cover with soil.
- b) Apply nutrients with care. Selenium and sulphur uptake influence the concentration of organosulphur compounds in the *Allium* and *Brassica* genera. High calcium uptake reduces respiration rates, delays ripening, increases firmness, and reduces physiological disorders and decay affecting post-harvest shelf-life. High nitrogen content reduces post-harvest shelf-life due to increased susceptibility to mechanical damage, physiological disorders and decay. Avoid nitrate application in excess, especially for leafy vegetables (for the EU market, see Reg. EU No. 1258/2011 for maximum levels allowed).
- c) Perform water analysis: for irrigation, at least every 2 years for well or groundwater or every year for surface water; for pre-cooling, every 6 months; for washing, every day.
- d) Use coloured labels for rapid identification of containers, for example: green label for containers filled with vegetables without problems; red label for containers filled with vegetables with possible problems/which need more attention during processing.

Adapted from Lundqvist *et al.* (2008), Jones and Short (2010) and USDA (2014).

If growers implement the activities outlined in the GAP recommendations, they will be a step nearer to meeting GlobalGAP standards. The recommended agricultural practices serve to reduce vegetable loss and waste not only in terms of “volume” but also in terms of quality. Incorrect vegetable management can result in loss of nutrients, reduction of organoleptic properties and reduced colour, taste, firmness and turgour; the resulting negative impact on marketability leads to a reduction in consumer confidence and ultimately to decreased profitability of the farm.

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Useful links for vegetable quality

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:157:0001:0163:EN:PDF>

http://mda.maryland.gov/foodfeedquality/Pages/good_ag_practices.aspx

https://international.jifsan.umd.edu/catalogue/course/good_agricultural_practices/#GAPs_manual_english

<http://www.brcglobalstandards.com/>

<http://www.canadagap.ca/manuals/manual-downloads/>

<http://www.gaps.cornell.edu/index.html>

http://www.globalgap.org/uk_en/

<http://www.fao.org/prods/gap/>

<http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/ProducePlantProducts/ucm064458.htm>

<http://www.iso.org/iso/home/standards/certification.htm>

http://www.kyagr.com/marketing/documents/GAP_selfaudit.pdf

<http://www.kyagr.com/marketing/GAP-resources.html>

<http://www.wnc.edu/files/departments/ce/sci/value01.pdf>

http://www4.ncsu.edu/~rmrejesu/Food_Safety_Risk/ag-709%20final%20printed.pdf

<https://www.ams.usda.gov/services/auditing/gap-ghp>