

# Food Losses and Wastes in the Armenian Agri-food Chains

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## **Abstract**

The issue of food losses is of high importance, since its prevention improves food security in the world's poorest countries. The aim of this study was to reveal volumes of food wastes and losses, as well as their preventions across the five steps of the supply chain – from production to final consumption. Data collection includes interviews and surveys with farmers, cold storage facilities, processors, wholesalers, food retailers as well as over 500 consumers in Yerevan.

Research findings are consistent with global food waste and loss study conducted by FAO in 2011 which suggests that in average low income country food losses are much higher in the beginning of the supply chain (agricultural production stage), than at the end (in distribution or consumption steps). In particular, the findings show that for commodities like fish and eggs around 20% loss occurs in agricultural production stage due to animal mortality. In the case of potato and wheat losses in production stage are 19% and 15% respectively. Identified reasons at this stage of the supply chain are the absence of the infrastructure in rural areas, underdeveloped irrigation system, low quality and high price of input supplies, and lack of skilled human labor in many branches of agriculture.

Main suggestions and recommendations on FLW include, but are not limited to educating and providing technical assistance to farmers, creating infrastructure for delivering fresh food to consumers, training participants of the supply chain, improving processing and packaging procedures and technologies, as well as improving food purchase planning.

**Keywords:** Food losses, Food wastes, Food supply chains, Armenia.

## **Introduction**

The issue of food losses is of high importance, since its prevention raises income and improves food security in the world's poorest countries. Food losses affect food security for vulnerable groups of population, on food quality and safety, on economic growth and on the environment. Reasons for the food waste and loss differ throughout the world and depend on the situation and certain conditions of a particular country. Food losses will be influenced by crop production choices, availability of infrastructure and facilities for transporting and preserving food, marketing chains and channels for distribution, and households purchasing and food use practices. No matter what the situation and circumstances in a country are, food losses have to be kept to a minimum.

Economically preventable food losses have a direct impact on the income of farmers and consumers. Since many small farmers live on the boundaries of food insecurity, a reduction in food losses could have a direct and considerable impact on their livelihoods. For vulnerable members of society the main concern is obviously to have access to nutritious, safe and affordable food products. Improving the efficiency of the food supply chain and reducing losses in this process will help to bring down the cost of food to the consumer, which is a very big issue in the countries like Armenia where poor families spend most of their income on food. Besides, agriculture is the main source of family income in rural areas, where poverty level is much higher. Armenia's dependency on agricultural products is quite high, so it is very important to utilize the commodities with minimum waste and loss throughout the value chain.

One of the main findings of previous studies in different countries was that food in low income countries is mostly lost during agricultural production and postharvest handling and storage, while in high income countries it is mostly wasted in the consumption stage (Gustavsson et al., 2012).

If we take a closer look at the volumes of agricultural production in Armenia, we will see that fruits and vegetables production holds the first line in terms of volumes produced. It also has a vital role in terms of dietary for consumers. This makes both the production and consumption of fruit and vegetables increasingly important. This sector, however, suffers greatly from postharvest losses. Some estimates suggest that in countries like Armenia about 30–40% of fruit and vegetables are lost during harvesting and postharvest stages of the value chain<sup>1</sup>. Some products are highly seasonal and may not be sold on the local markets for profit, while international markets may reject fruits and vegetables containing unauthorized pesticides and with inadequate labeling and packaging.

## Study Objectives

The aim of this research is to find and analyze data on food waste and loss as it goes through different stages of the food supply chain, starting from harvesting and ending with consumption. The commodity groups covered are: “Cereals”, “Roots & Tubers”, “Fruit & Vegetables”, “Meat”, “Fish & Seafood” and “Milk”. The steps in the food supply chain considered are: “Agricultural production”, “Post-harvest handling and storage”, “Processing and packaging”, “Distribution” and “Consumption”.

Four agro-food value chains have been selected to analyze the critical loss points based on the economic importance for the country in terms of employment generation, contribution to food security, impact on smallholders or share in agricultural production of the region. The selected value chains are: wheat, potato, tomatoes and milk. The study focused on assessment of food waste and loss during harvesting, postharvest handling and storage, processing, distribution, and consumption of the selected products. The research aimed at providing recommendations for the loss minimization across the supply chain.

## Methodology and Approach

Food losses refer to the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. Food losses take place at production, postharvest and processing stages in the food supply chain (Parfitt et al., 2010)<sup>2</sup>. Food losses occurring at the end of the food chain (retail and final consumption) are rather called “food waste”, which relates to retailers’ and consumers’ behavior. (Parfitt et al. 2010).

In the case of Armenia food waste and losses throughout the supply chain were revealed in the process of surveys and interviews with main participants at each step in the supply chain. Graphical representation of stages of supply chain, participants and FLW elements for each step in vegetable commodities in Armenia is presented in Figure 1.

For the current study we used primary and secondary data sources as follows:

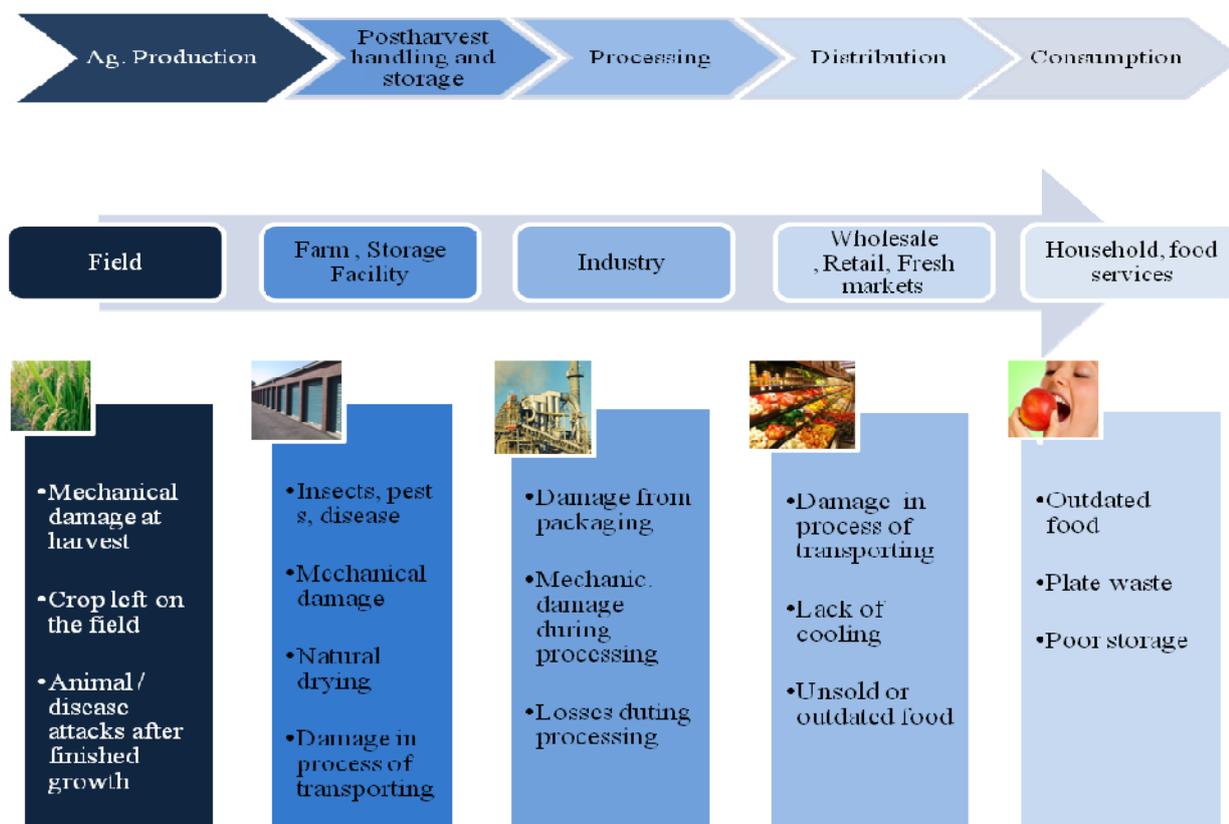
- **Primary information sources** - Consumer surveys, Interviews with business support organizations, Interviews and surveys with members of value chain - farmers, supermarkets, storage facilities, wholesalers, traders on fresh markets. Interviews with Ministry of Agriculture experts.

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<sup>1</sup> Postharvest Management of Fruit and Vegetables in the Asia-Pacific Region, Edited by Dr. Rosa S. Rolle, APO 2006, ISBN: 92-833-7051-1 (joint APO/FAO publication).

<sup>2</sup> Parfitt, J., Barthel, M. & Macnaughton, S. Food - 2010, waste within food supply chains: quantification and potential for change to 2050, *Phil. Trans. R. Soc.*, vol. 365

**Figure 1. Stages in value chain and FWL elements in each stage for vegetable commodities and products in Armenia.**



Source: Authors.

➤ **Secondary information sources** - FAOSTAT data, Official statistics published by Armenian Statistical Service, FAO reports, Ministries of Agriculture, Economy and Trade reports, World Bank reports, Customs service's reports, Previous studies of ICARE.

Volumes of food produced within the given commodity groups have been identified, based on official statistical data available on the State Agencies' and international organizations' websites. Several products have been selected from each commodity group, based on the economic significance of particular product for region or Marz - employment generation, contribution to foreign exchange, largest impact on smallholder producers, or food security for vulnerable groups.

For quantifying food loss, we have collected information on share of food lost and wasted at each step of the value chain of each commodity and then applied conversion factors provided by FAO 2011 Global Food Losses and Food Waste<sup>3</sup> report. For revealing actual food wastes across the supply chain we have:

- ✓ conducted interviews with farmers, to find out product waste during harvesting and postharvest handling and storage,
- ✓ contacted cold storage facilities, wholesalers for obtaining data on FWL during postharvest handling and storage,

<sup>3</sup> FAO Global Food Losses and Food Waste, 2011 <http://www.fao.org/docrep/014/mb060e/mb060e00.pdf>

- ✓ contacted selected dairy processors and canneries to find out FWL during processing and distribution (since most of dairy products are returned to processing plants, if spoiled in the retailing stage or brought back to the retailer by consumers),
- ✓ interviewed several wholesalers for revealing FWL during postharvest handling and storage and distribution,
- ✓ interviewed 8 supermarkets, 8 medium size grocery stores and 36 small shop holders, 2 butcher's outlets and 15 fruits and vegetables resellers on 2 open markets<sup>4</sup> to reveal FWL during distribution step,
- ✓ Interviewed 506 customers in Yerevan to get information on FWL during consumption stage.

To have results compatible with previous studies conducted by FAO we have used the same model to show the flow of commodity in FBS<sup>5</sup> (Appendix 1). The only difference is that within utilization elements we have omitted “waste”, since the data on waste has been obtained directly from supply chain participants. For detailed FWL calculations we have used 2012 data from ARMSTAT.

### **Assessment of Food Wastes and Losses in Selected Agri-Food Chains**

For Critical Loss Point analysis we selected four agri-food chains, based on their economic importance for the country in terms of employment generation, contribution to food security, impact on smallholders or share in agricultural production of the region:

**1. Wheat:** The grain sector is important for Armenia due to geopolitical situation, elimination of poverty and assurance of food security in case of emergencies. The grain price and supply fluctuations directly impact entire population and particularly poor segment, which can hardly sustain living. This urged government to prioritize grain production and development, and implement programs which aim at increasing production of grain and in particular wheat in Armenia. Wheat import and production data shows that self-sufficiency in wheat production is quite low and Armenia greatly depends on international wheat suppliers, mainly Russia (more than 50% of wheat imports).

**2. Potato:** Potato is considered a staple food and along with wheat takes care of the food security issues. Potato production is mainly concentrated in Gegharkunik Marz and is considered main source of income for many farmers. Almost 50 % of potato produced in the country originates from Gegharkunik marz.

**3. Tomatoes:** There was a big tomato production in Armenia during Soviet Union times and Armenia was supplying to other Soviet Union countries around 100,000 tons of tomato annually. In Armenian households tomato is the main vegetable that is preserved in summer-time and used in food throughout the year. The importance of tomato in Armenia has been validated by the fact, that tomato has been a leader in Armenian market in terms of volumes of production and consumption for many years.

**4. Milk:** Supply chain of milk is included in the list of priority agri-food chains, since this is a commodity that has a huge impact on smallholders. In 2008 across the country there were 173.7 thousand dairy farms, and over 96% of those farms held less than 7 heads.

Table below provides detailed information on product category volumes.

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<sup>4</sup> See the detailed FWL weights allocation among different distribution agents in Appendix 4.

<sup>5</sup> FAO Global Food Losses and Food Waste, 2011 <http://www.fao.org/docrep/014/mb060e/mb060e00.pdf>

**Table 1. Overview of selected commodity groups in 2012 (thousand tons).**

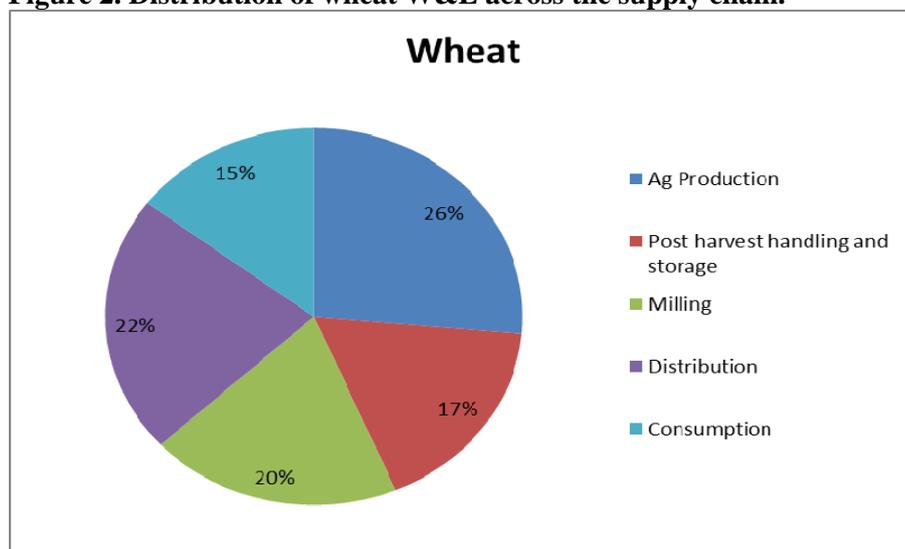
	Produced in the country	Imported	2012 Stock variation	Exported	Used for feed and seed	Processing	Available for use in food
Wheat	243.1	502.5	-179.2	7.6	115.6	3	440.2
Potatoes	647.2	7.8	-84.1	1.1	360.7	0	209.1
Tomatoes	265.2	0.3	6.2	5.1	8.1	0	265.8
Milk and milk products (excl. butter)	618.2	134.8	-0.3	3.1	70.4	0	687.8

Source: NSS RA

***Critical loss points by each product***

**Wheat:** Total wheat wastes and losses throughout the supply chain in Armenia added up to 128.7 thousand tons (detailed calculation is provided in Appendix 3), which is more than half of the wheat produced domestically. The FLW for wheat is about 30% from the wheat available for human consumption.

**Figure 2. Distribution of wheat W&L across the supply chain.**



Source: Own calculations.

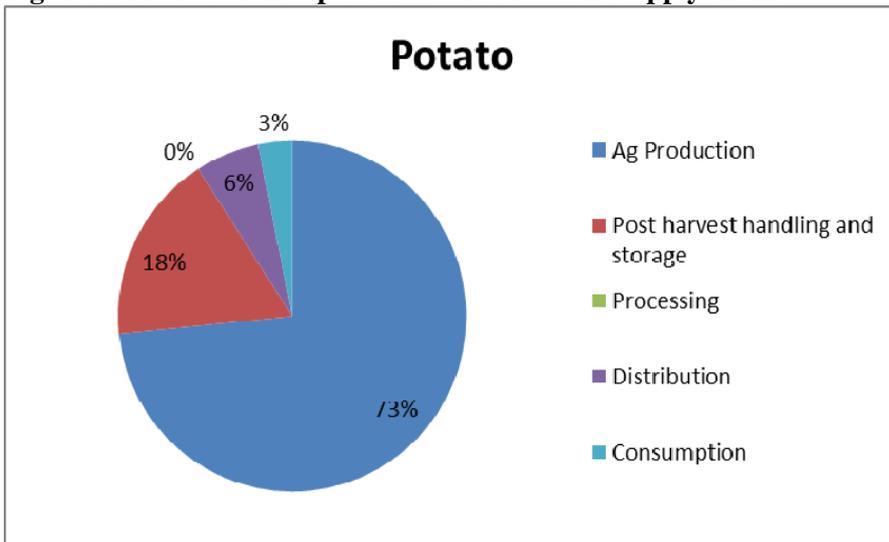
The distribution of waste and loss by the steps of the supply chain (

Figure 2) shows that the biggest share of FLW occurs during agricultural production and distribution steps. Losses during milling include natural processing loss.

**Potatoes:** A total volume of potato wastes and losses throughout the supply chain in Armenia was 66.6 thousand tons, which is nearly 32% of potato available for food. The distribution of waste and loss by the steps of the supply chain (

Figure 3) shows that the biggest share of FLW occurs during agricultural production step.

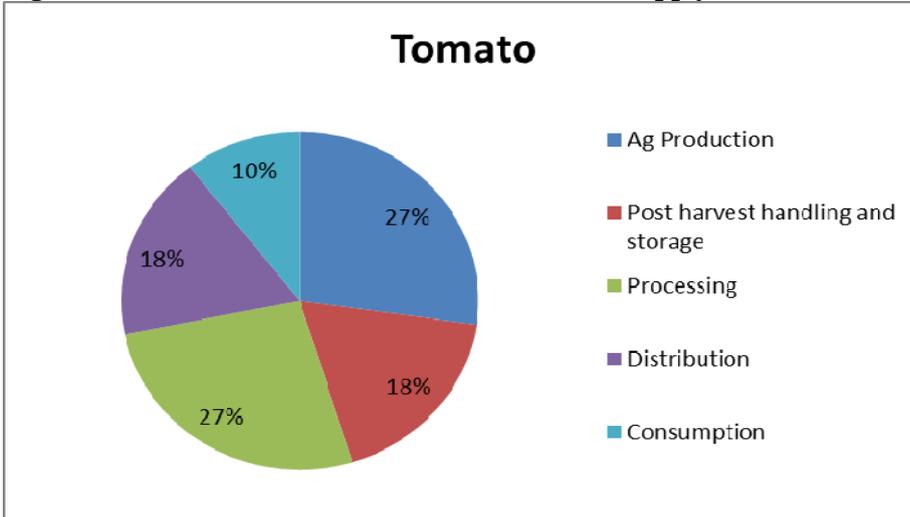
**Figure 3. Distribution of potato W&L across the supply chain**



Source: Own calculations.

**Tomatoes:** total volume of tomato wastes and losses throughout the supply chain in Armenia was 22.8 thousand tons, which makes up almost 9% of total tomato volumes produced. The allocation of waste and loss by the steps of the supply chain shows that the biggest share of FLW occurs during distribution step, followed by agricultural production and processing.

**Figure 4. Distribution of tomato W&L across the supply chain.**



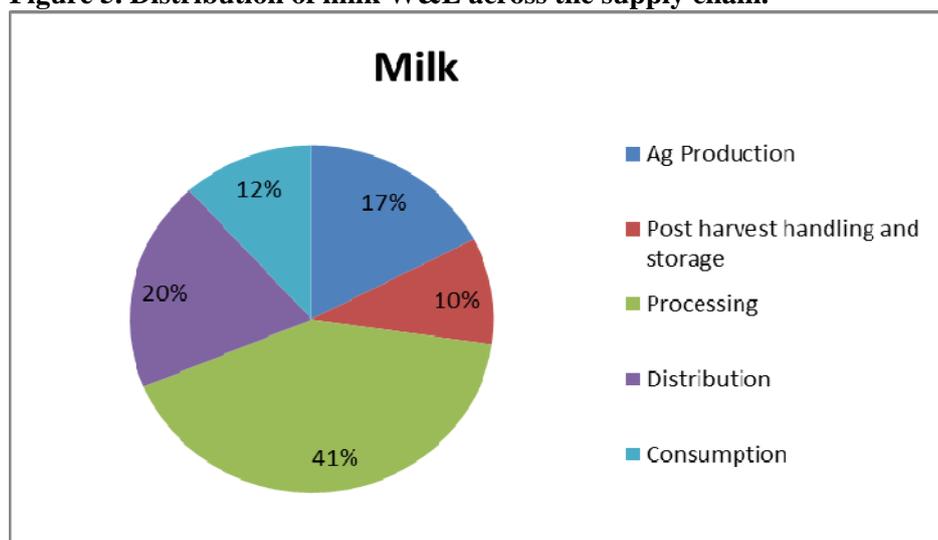
Source: Own calculations.

Here losses in the distribution step were mainly due to losses of produce on the open markets. About one third of tomato sold in Armenia is distributed through open/fresh markets. Tomato harvest season starts in mid-summer and lasts until early fall. This is the hottest period in Armenia. Open markets are not equipped with refrigerators or cool areas where resellers may keep fruits and vegetables.

**Milk:** A total volumes of losses and wastes of milk and products made from milk added up to 66.5 thousand tons, which makes about 10% of total volume of row milk produced in the country. The largest portion of FLW can be observed in the production stage, although most of it happens

because of technological procedures. Wastes and losses are sizable also in agricultural production (cow mastitis), and in distribution steps (due date expiration).

**Figure 5. Distribution of milk W&L across the supply chain.**



Source: Own calculations.

To obtain FLW data for commodity groups, there were conducted several surveys of supply chain participants and numerous interviews with industry experts. Table 2 below provides detailed representation of FLW percentages in each step of the chain.

**Table 2. FLW percentages during each step of the supply chain.**

	Ag. production	Post-harvest handling and storage	Processing and packaging	Distribution	Consumption at household level
Cereals	15%	5%	6%	7%	5%
Roots & Tubers	19%	6%	0%	3%	1%
F&V <sup>6</sup>	10%	4%	3%	10%	3%
Meat (Beef)	1%	0.1%	1%	1%	1%
Fish and Seafood	20%	0.1%	0.2%	3%	1%
Milk	2%	0.1%	4%	2%	1%
Eggs	23%	1%	0.1%	0.1%	0.1%

Source: Own data (Expert opinion and surveys).

## Priority actions and policies for reduction of Food Loss and Waste

FLW previous studies have proven that in low-income countries food is mostly lost during the production-to-processing stages, while in the industrial countries – in distribution and consumption stages of the supply chain. Our study findings mainly agree with this statement.

In this section we will describe causes for FLW and will suggest prevention mechanisms for each step of the supply chain.

<sup>6</sup> The survey data covers only apples and tomatoes. Since fruits make up the higher share within this commodity group, and since most of fruits are more perishable than apples, we have estimated that waste and losses in the commodity group will be about 2 % higher, than the average losses for the two products.

## *Agricultural production:*

### **Causes of food waste and loss**

- **Improper harvest timing**  
Lack of farmer knowledge about harvest timing leads to losses in volumes of the product (overripe fruits turn soft and are hard to store, while under ripe fruits dry out and lose weight). Sometimes crops might be harvested early because farmers want to deliver those to the market while the prices are high.
- **Improper harvesting procedures and lack of mechanization**  
Lack of farmer knowledge about harvesting procedures, for example irrigating before the harvest, may cause fungi that can spoil the sizable portion of the harvest. After the collapse of the Soviet Union farms were privatized, but farmers were not rich enough to replace old farm machinery. Some crops just cannot be harvested with human labor and without major losses. Because of these poor combine harvesters there is a huge loss during the harvesting phase.
- **Animal mortality during breeding**  
Most of livestock farmers in Armenia are smallholders, who often cannot afford a veterinary consultancy or all necessary immunizations. Since animals are not kept in closed farms, any disease can wipe out the grazing livestock population from the meadows.

### **How to prevent food losses and waste**

- **Education**  
Most of agricultural production in Armenia is run by smallholders, who do not have proper knowledge in the field of agronomy. Specialized trainings on harvesting and cultivating certain crops would increase the harvest volumes. Develop strong linkages between extension centers and farmers.
- **Technical support**  
Financial investments are needed for obtaining farm mechanization. The idea of several small farmers sharing same machinery may be promoted and implemented. The idea of farm machinery cooperatives (e.g. case of France) might be useful to analyze and apply in Armenia.

## *Post-harvest handling and storage:*

### **Causes of food waste and loss**

- **Poor storage facilities**  
Main reason for food loss in this stage of the supply chain is limited number and access to refrigerated storage facilities. Especially fruits and vegetables have to be kept under the same temperature throughout the storage period. Farmers do not have financial means to keep produce in commercial storages for several months. There is also lack of cold storage facilities in Armenia; some were established under the Millennium Challenges Armenia (MCA) project, but do not fully function.
- **Rodents and pests**  
Potato farmers in Gegharqunik marz informed that they had rodents, which wiped out almost 20% of potato after harvest on the fields and in the storage rooms.
- **Poor storage techniques and know-how**  
Farmers use same storage areas (mostly in the basement of own house) from year to year. Those areas need to be sprayed for certain fungi and diseases every time before the new harvest. Many farmers in Armenia do not even know that a fresh produce can get spoiled in

the storage room because the area was not ventilated properly. Clearly, there is insufficient knowledge/capacity to ensure the adequate post-harvest handling and treatment of agricultural products.

### **How to prevent food losses and waste**

- **Education**

Farmers and those who perform transportation and delivery need to be trained on commodity storage and handling skills. Farmers have to be informed about humidity and temperature conditions necessary for storing a particular good.

- **Technical support**

Cold chain storage rooms with back up power system have to be installed and operated, especially in areas where there are fruits orchards and vegetable fields. High quality pesticides have to be available to combat pests and rodents with no harm for the harvest. Milk collection points need to have means for milk inspection, and have to comply with certain hygiene standards.

There is no data about cold storages, their capacity, technical conditions, etc. It will be useful for Armenia to make an inventory of all cold storage facilities and their capacities and later formulate clear proposals on how many new units are needed.

### ***Processing and packaging:***

#### **Causes of food waste and loss**

- **Processing procedures**

Agricultural products, especially fruits and vegetables have very high seasonality, that's why most of them are processed and sold later as juices or preserves. A few processors have fully renovated production lines and high tech processing equipment; others are operating on the base of a processing plant established during Soviet times. While exploiting obsolete equipment factories incur higher wastes of a produce during processing.

- **Poor packaging**

Quite often, when the produce is sold on the open markets, farmers or intermediaries deliver it in plastic crates, wooden boxes or plastic bags. This might cause large amounts of waste due to mechanical damage and decrease product's appeal to the supermarkets.

### **How to prevent food losses and waste**

- **Processing technologies and equipment**

Improvement of processing technologies, as well as new production lines and equipment can decrease food waste in the processing step. There are certain tools to measure resource efficiency management systems in the companies (e.g. PROREMAS). It's advisable to train the processors in such tools which will allow companies to identify gaps and inefficiency points and come up with solutions.

- **Packaging**

New packaging gears, like special boxes for transporting berries or soft fruits and vegetables will increase the product shelf life significantly.

### ***Distribution:***

#### **Causes of food waste and loss**

- **Distance from main food markets**

Quite often farmers have to transport agricultural products to main markets in the city, where they can reach the final consumer or deliver produce to wholesale or retail points. This becomes very difficult if farm is located far from Yerevan (main consumption point for agricultural products), or if the farmer does not possess and cannot rent a truck.

- **Lack of ability to sell own produce**

During the harvest season (especially for perishable fruits and vegetables) farmers may not be able to take care of the delivery issues, since they are very busy harvesting the product on the fields. Even if the farmer could overcome this obstacle and could get to the market in Yerevan, he may still be unable to sell the produce because of lack of networking and specialization in selling.

- **Inadequate selling conditions**

Most of the fresh food in Armenia is sold on open air fresh markets. Sellers set the produce on the counter or leave in the boxes under the sun. By the end of the hot summer day the unsold goods are either sold for home processing for a very low price or are set aside for animal food.

- **Short expiration dates for dairy products**

Fresh pasteurized milk has a shelf-life of 4 days at 4°C but in reality, milk frequently becomes spoilt before the expiry date. This is not the fault of the processors or distributors, but is mainly due to the very poor hygienic quality of raw milk collected or due to improper conditions in milk collection points.

### **How to prevent food losses and waste**

- **Establishment of farmer cooperatives**

Farmer's cooperatives creation and establishment has been successfully supporting farmers in transportation and distribution activities. Joint resources will allow having trucks owned by the cooperative and keeping a booth in a big open market. In this case transportation and distribution activities will not destruct farmers from their main work and constant presence in the market will bring recognition and create network of customers.

- **Development of marketplace**

To reduce food waste and loss at the distribution step, the traditional market system needs to be developed or changed. Fresh markets need to have covered shops and refrigerated storage facilities to avoid large volumes of food loss.

### ***Consumption:***

#### **Causes of food waste and loss**

- **Inadequate storing conditions**

Households in Armenia often buy products in bulk and pay lower price for it. Commodities like apples, potatoes and onions are purchased in late fall and kept in cool storage rooms to be used during the winter months. Inadequate storage conditions lead to spoilage of this food and consumers end up paying more.

#### **How to prevent food losses and waste**

- **Improved storage conditions**

To reduce food waste and loss during the consumption step, households' food storage could be improved.

- **Food purchase planning**

Social messages on food purchase planning may decrease unnecessary large volumes of food purchased by households.

### **Acknowledgement**

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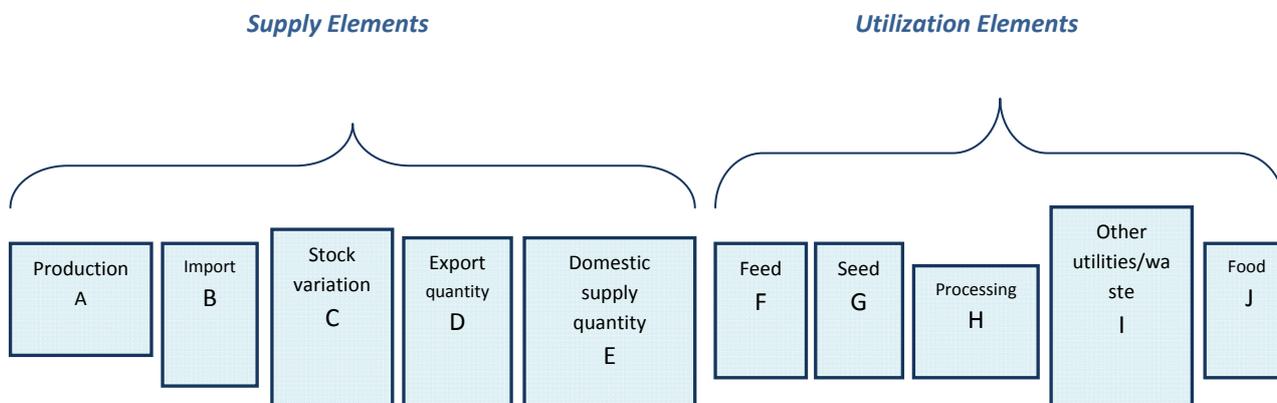
NSS - National Food Balance of the RA

NSS - Socio-Economic Situation in RA, January-December 2012  
[http://www.armstat.am/file/article/sv\\_12\\_12a\\_122.pdf#page=1&zoom=auto,0,179](http://www.armstat.am/file/article/sv_12_12a_122.pdf#page=1&zoom=auto,0,179)

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## Appendix 1. Food Balance Sheets

A FBS shows the patterns of a country's food supply during a specific period of time. For each food item the domestic supply (E) equals the sum of production (A), imports (B) and stock variations (C). Food available for human consumption (J) is left after withdrawing utilization sources such as exports (D), feed (F), seed (G), processing (H) and waste or other utilities (I).



- |   |  |
|---|--|
| <b>A Total domestic production:</b>         | reported in primary crops for crops; carcass weight for meat; live-weight equivalent for fish and total production leaving the manufacture for processed commodities.  |
| <b>B Total domestic import:</b>             | all movements of the commodity in question into the country/region.  |
| <b>C Stock variation:</b>                   | changes in foremost government stocks.   |
| <b>D Export quantity:</b>                   | all movements of the commodity in question out of the country/region.  |
| <b>E Domestic supply quantity:</b>          | Sum of A, B, and C   |
| <b>F Feed:</b>                              | the amounts of the commodity in question used to feed animals.   |
| <b>G Seed:</b>                              | the amounts of the commodity in question used for reproductive purposes, e.g. seed, planting, eggs for hatching or fish for bait.  |
| <b>H Processing:</b>                        | the amount of the commodity available for human consumption as part of processed food products, containing several commodities.  |
| <b>I Other utilities/waste<sup>7</sup>:</b> | the amounts of commodity lost during handling, storage and transport between production and distribution as well as amounts of the commodity used for non-food purposes, e.g. oil for oil production and wheat for bio-energy. |
| <b>J Food:</b>                              | all forms of the commodity available for human consumption, e.g. wheat flour, vegetable oils etc.  |

All volumes in the FBS are reported in primary product or primary product equivalents. Food Balance Sheet data will partially be used in this survey. However, taking into consideration that the data (waste and loss allocation factors) for FBS has been collected back in 2007, and since no research on food wastes and losses was conducted in Armenia before, thus the waste and loss proportions may not reflect the country specifics, we will get own numbers based on the surveys, interviews and expert opinions.

<sup>7</sup> According to FAOSTAT Food Balance Sheet "Other utilities/Waste" category includes "the amounts of commodity lost during handling, storage and transport between production and distribution as well as amounts of the commodity used for non-food purposes, e.g. oil for oil production and wheat for bio-energy." Since within the research we calculated country specific waste and losses data, here on the mass flow figure we will refer only to waste occurring due to other uses of the commodity.

## Appendix 2. Quantification of results

Food waste and loss will have to be calculated at each stage of the value chain as a percentage of the volumes of produce introduced to that stage. In some stages, like Agricultural Production (Harvesting) it will be practically impossible to tell what the exact volume of produce available for harvesting was. Here we will introduce the idea of Potential Production, which will represent this volume. Potential Production equals the sum of Production harvested and reported by the farmer and Waste (produce lost on the field – damaged by pests, birds, rodents, weather conditions, etc.).

$$\begin{array}{|c|} \hline \text{Potential Production} \\ \hline \text{PP} \\ \hline \end{array} = \begin{array}{|c|} \hline \text{Production} \\ \hline \text{P} \\ \hline \end{array} + \begin{array}{|c|} \hline \text{Waste} \\ \hline \text{W} \\ \hline \end{array}$$

For the step Agricultural Production, where we do not have Possible Production volumes, we will use the following formula to calculate waste:

$$W = r * P$$

Where

W is waste at the current stage  
r is the waste rate as a fraction of Production  
P is Production

In general for other steps of Supply Chain the formula for waste will be:

$$W = r * PP$$

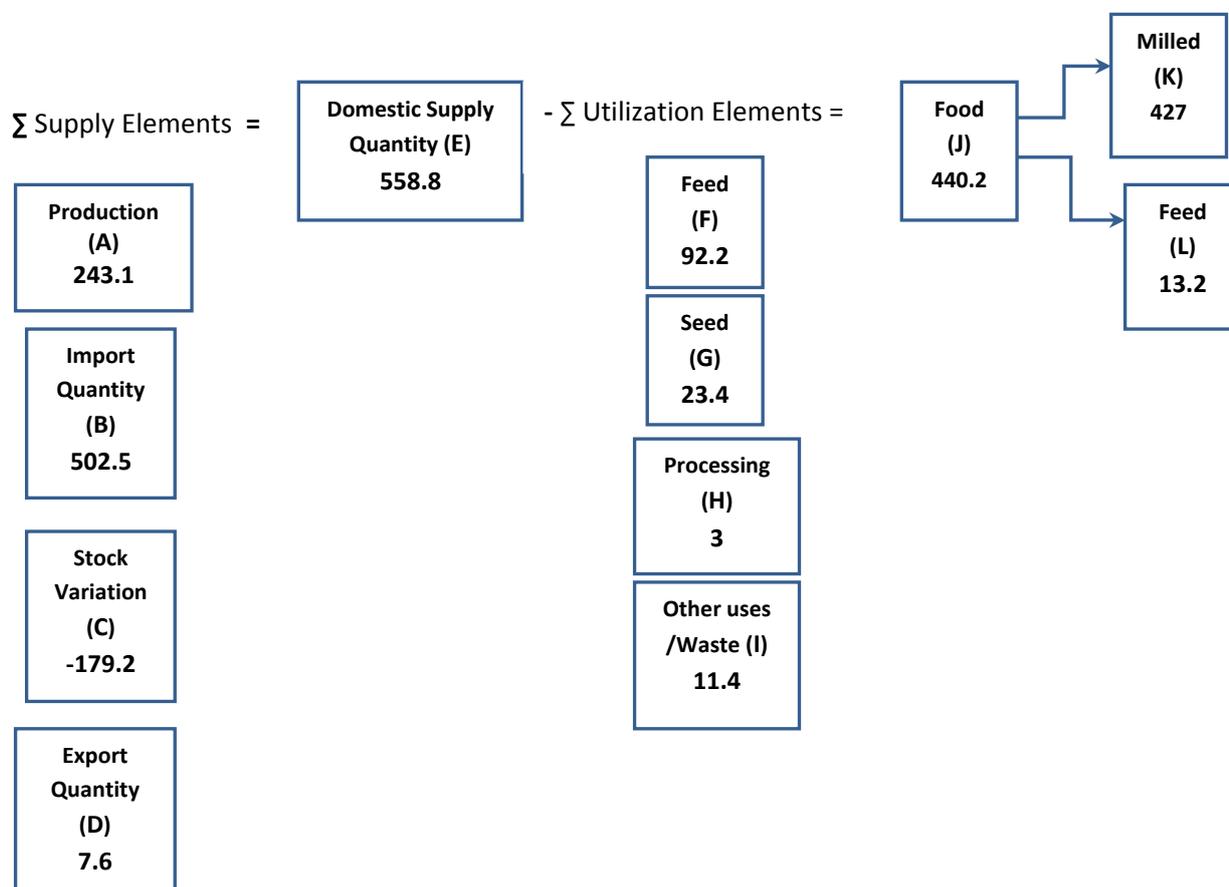
All data is reported in primary product equivalent (while speaking of milk losses, we will introduce all dairy product losses in milk equivalent).

Total waste for all steps will be equal sum of Waste from each step multiplied by corresponding edible weight conversion factors.

### Appendix 3. Example of calculation of food losses and waste

The sample calculation for food losses and waste was done on the example of wheat. The figure below shows the mass flow of wheat in Armenia in 2012 (thousand tons).

Figure 6. Mass flow of wheat in Armenia in 2012, (thousand tons).



Processing (H) – the amount of the commodity available for human consumption as part of processed food products, containing several commodities was very small.

Other uses/Waste (I) for the current study it was recalculated, so we omitted the waste data reported in the food balance sheet of the FAOSTAT.

*Waste percentage in each step of the food supply chain for wheat:*

- Agricultural production – 15%
- Postharvest handling and storage – 5%
- Processing and packaging (milling and packaging) – 6%
- Distribution – 7%
- Consumption – 5%

*Calculation of primary equivalent wheat losses and waste in each step of the FSC:*

- Agricultural production:  $0.15/(1-0.15)*243.1 = 42.9$
- Postharvest handling and storage:  $0.05*440.2 = 22.01$
- Processing and packaging (milling and packaging):  $0.06*(440.2-22.01) = 25.09$
- Distribution:  $0.07*(440.2-22.01-25.09) = 27.52$
- Consumption:  $0.05*(457.98-22.01-25.09-27.52) = 18.28$

Out of domestic supply of wheat (558.8), some part (115.6) was allocated as a feed and seed, so the losses in the agricultural production stage were not pure losses from the wheat intended for human consumption, which means the loss of 42.9 has to be adjusted for wheat used for feed, seed. The portion of loss in agricultural production that was not intended for human consumption is  $(115.6/558.8)*42.9 = 8.87$ . This leaves the loss of wheat intended for human consumption equal to  $42.9-8.87=34.02$  thousand tons.

*Conversion factors on edible wheat losses and waste in each step of the FSC:*

Agricultural production loss:  $34.02*0.97 = \mathbf{33.00}$

Postharvest handling and storage loss:  $22.01*0.97 = \mathbf{21.34}$

Processing and packaging (milling and packaging) loss:  $25.09*0.97 = \mathbf{24.34}$

Distribution loss:  $0.07*(440.2-21.34-24.34) = \mathbf{27.61}$

Consumption loss:  $0.05*(440.2-21.34-24.33-27.61) = \mathbf{18.34}$

We also had a 2% reported loss that occurred on the field before the harvest, when the wheat was ready, but the harvest got delayed or got affected by rodents and pests. So Possible Production has to be more than Production (243.1) by: Difference between PP and P =  $0.02/(1-0.02)*243.1 = 4.96$

Taking into consideration allocation and conversion factors, the loss will be:

$(4.96-4.96*0.15)*0.97 = \mathbf{4.09}$

Total loss comes to **128.7** thousand tones, which is about **29%** lost from the wheat available for human consumption.

#### Appendix 4. Allocation of fruits and vegetables between various distribution agents

Fruits and vegetables in Armenia are sold through wholesale and retail agents. The biggest wholesale market is in Malatia, while locations of retailers are quite diverse. Retail fresh fruit and vegetable segment can be categorized into agricultural markets, shops, supermarkets and other areas (including farmer's market on Kasyan street).

Based on the retail trade sector study conducted by America CJSC consulting company, as well as previous reports of ICARE and own calculations and estimations, we assembled the allocation of fruits and vegetables between various retailers as follows.

Table 3. Allocation of F&V between different distributing agents.

Retailing agents	Proportion of F&V sold
F&V kiosks/shops	<b>44%</b>
Open/fresh markets	<b>28%</b>
Supermarkets	<b>24%</b>
Other	<b>4%</b>

Source: America and own data.

Based on this data we have assigned weights to FWL occurring in the distribution stage. In our example resellers on the fresh markets have reported loss in tomato of 8%, supermarkets have reported 6% loss and small specialized kiosks – 1% loss. Taking into consideration proportion of volumes (weights) of fruits and vegetables sold by each of those agents, we come up to the total tomato waste of 4% in the distribution step:

$$0.44*1\%+0.28*8\%+0.24*6\% = 4.1\%.$$