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INTERNATIONAL INSTITUTE OF REFRIGERATION

THE ROLE OF REFRIGERATION IN WORLDWIDE NUTRITION



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**6th Informatory Note
on Refrigeration
and Food**



**“ The deployment of an
efficient cold chain is
essential for
global food security ”**

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The Role of Refrigeration in worldwide nutrition

Over a year, the food products that should benefit from refrigeration represent 1.661 million tonnes (46 % of food production) after deducting the various agricultural and post-harvest losses.

Yet only 47 % of this tonnage is refrigerated, resulting in losses amounting to 13 % of food production. These losses are particularly high in developing countries, where the available refrigeration capacity is much lower than in developed countries.

These 475 million tonnes of lost food could be saved thanks to refrigeration and could theoretically feed 950 million people a year. This figure must be put in perspective with the fact that in 2018, 821 million people were undernourished and that the world population is still to grow by 2 billion by 2050.

These figures were evaluated by the IIR from the latest FAO data on the basis of a model assessing food losses for each category of perishable food products and for each stage of the food supply chain.

Based on these estimates, this Information Note aims to demonstrate the essential role that efficient cold chains can play in improving global food security.

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It was reviewed by Gérald Cavalier (President of the IIR Science and Technology Council), Didier Coulomb (Director General of the IIR), Paul de Larminat (Johnson Controls), Michel Havet (ONIRIS), Alain Le Bail (President of Commission C1) and Sylvia Minetto (President of Commission D2).

¹ This Informatory Note is an update of previous versions published by the IIR in November 1996 and June 2009.

Introduction

“Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary and food preferences for an active and healthy life”^[1]

Nowadays, many people still suffer from undernourishment all around the world, especially in developing countries. Thus, providing both adequate food supply and food quality remains a major global challenge, especially with the increase of the world population from 6.12 billion in 2000 to approximately 7.7 billion currently, with projections reaching 9.7 billion by 2050^[2]. Such growth will add more pressure to the situation and the demand for food will significantly increase, so more food will have to be produced in order to meet the needs of future generations. However, the relevant question to ask is: is increasing production the only option to ensure food security ?

FAO estimates that each year, about one third of all food produced for human consumption in the world is lost or wasted^[3]. It therefore seems pertinent to look for a better way to use what is already produced by focusing on reducing food losses rather than massively increasing world production. Such a solution would help minimise the negative impact of excessive agricultural activities on the environment, the society and the economy. Food losses can occur at all stages of food supply chain and an important amount of food is lost mainly because of a lack of refrigeration. Refrigeration plays a key role in post-harvest processes by slowing down bacterial growth, increasing shelf life and preserving the nutritional and organoleptic properties of foodstuffs. Thus, increasing the use of refrigeration would make it possible to reduce food losses especially in developing countries with the lowest refrigeration capacity.

The aim of this Informatory Note¹ is to emphasize the importance of refrigeration by proving that a more efficient cold chain can significantly reduce food losses and thus improve food safety and security in a sustainable way.

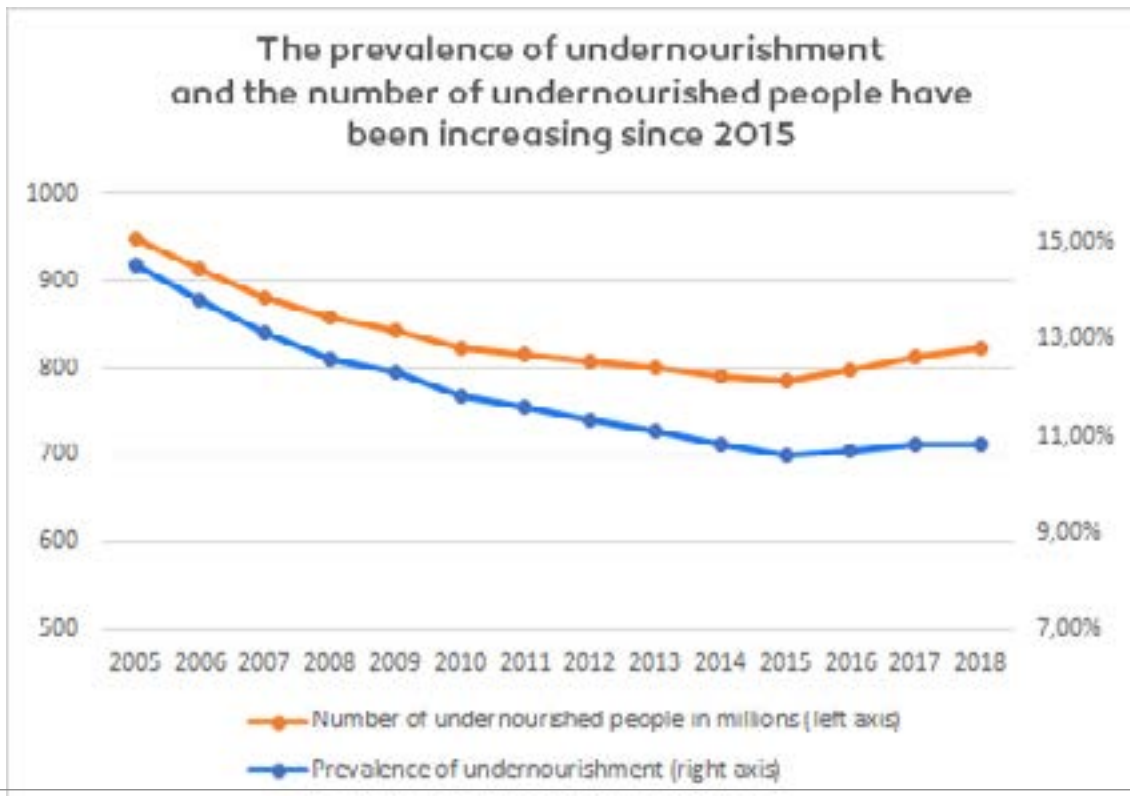
An increase of undernourished people since 2015

The evolution of the prevalence of undernourishment worldwide, as illustrated in figure 1, shows that despite a decrease in recent decades, there

is again an increase in food insecurity, resulting in **821 million undernourished people in the world in 2018** [4].

Figure 1:

Prevalence of undernourishment and number of undernourished people in the world.

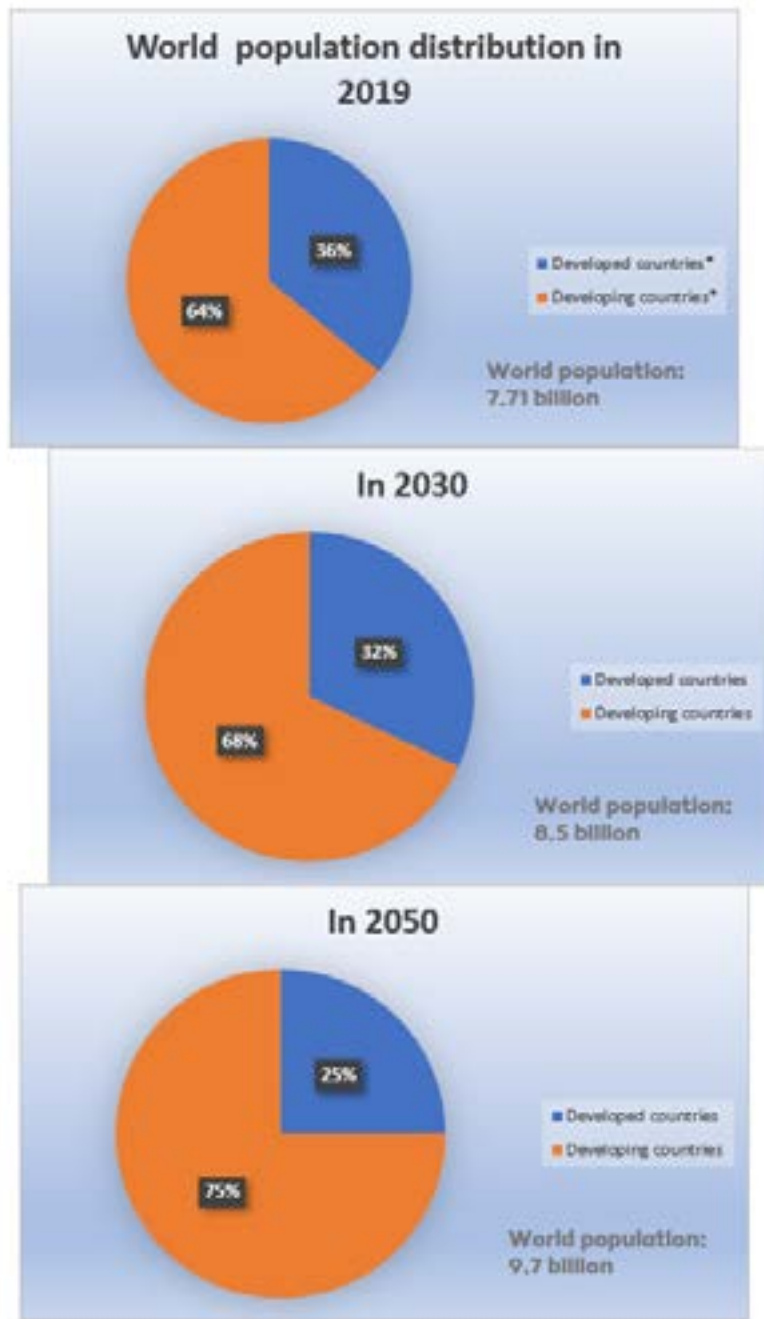


The World Food Summit in 1996 had set a target of reducing by half the number of undernourished people in the world by the year 2015. Unfortunately, this goal was not achieved since there were 785.4 million undernourished people in 2015 [4] instead of 410 millions. Thus, the Summit on Sustainable Development in September 2015 adopted the 2030 Agenda for Sustainable Development,

including the Sustainable Development Goal N°2 “Zero Hunger” with the target to eradicate undernourishment and attain food security by 2030. However, considering the actual trends, this target should not be reached by 2030 and more people should remain food insecure especially in developing countries* that will host over 68 % of global population by 2030 (figure 2) [2].

Figure 2:

Trends in population from 2019 to 2030 [2]



*The categorization of the world into developed countries and developing countries is based on the indicators of the United Nations Organisation [9].

There is no doubt that many solutions exist to raise food production, but they are either limited or environmentally harmful [6, 7]. Therefore, another lever of

action would be reducing post-harvest food losses to increase food availability in a more sustainable manner.

More than 1,600 million tons of food lost and wasted every year

The amount of food lost or wasted² annually at the global level is estimated by the IIR to be over 1,600 million tons for a world agricultural production of 6,300 million tons [8]. Reducing these huge losses at all stages of food supply chain represents a great opportunity to provide more food and reduce the number of undernourished people all over the world.

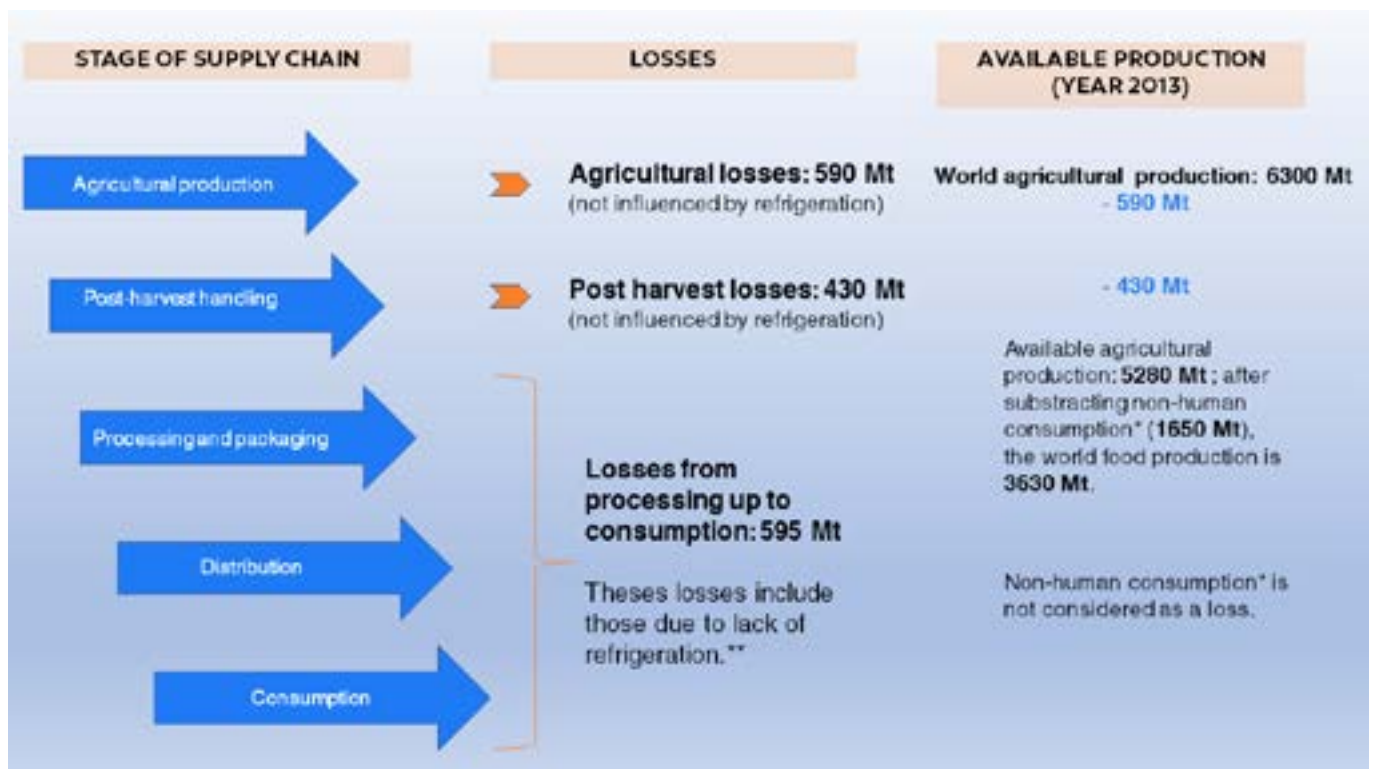
Before reaching the consumer, food follows all stages of supply chain. A considerable amount of food is lost or wasted at each stage. The IIR has

estimated food losses and waste throughout the supply chain based on a new assessment model taking several factors into consideration. The methodology used to build this model is presented in a document annex [8].

The IIR assessment of food losses and waste, based on the latest available data provided by FAO in 2013 [9], yields the results presented in figure 3:

² An important part of food loss is “food waste” which refers to the discarding or alternative (non-food) use of food that was fit for human consumption – by choice or after the food has been left to spoil or expire as a result of negligence.[5]

Figure 3:
Food losses and waste from agricultural production up to consumption



*Non-human consumption refers to the amounts of commodity used to feed animals, seeds and other utilities [6].

**losses due to a lack or insufficiency in refrigeration can occur at the stages of processing and packaging, distribution and consumption and have little impact on the first two stages. For more details about these losses see the document annex of this note [6]

This assessment shows that in 2013 approximately 25.7 % of total agricultural production in the world is lost or wasted during food supply chain with high percentage losses in vegetables, cereals, roots and fruits [8]. Food losses by regions of the world and by commodity groups, including losses due to lack of refrigeration are detailed in the document annex of this note [8].

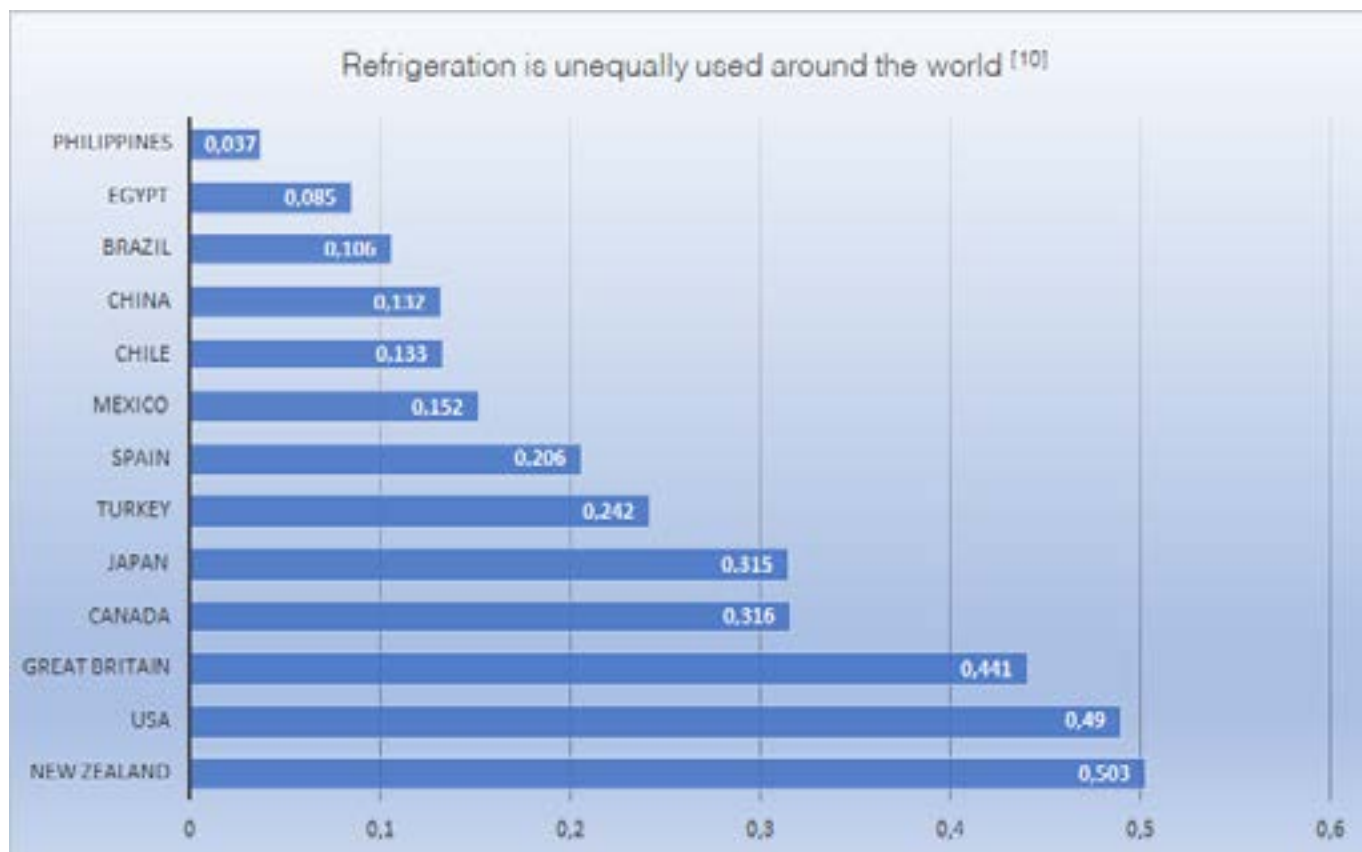
The IIR assessment model shows also a surprising and remarkable fact: while developing countries have high percentages of food losses, mainly because of the lack of infrastructure (cold chain, distribution, processing...), developed countries have higher food losses per capita due to waste related to consumption patterns, habits and the availability of food.

13 % of food in the world is lost due to a lack of refrigeration

The assessment of losses due to a lack of refrigeration infrastructures concerns the stages of processing and packaging and distribution and consumption, which are influenced by the use or not of refrigeration [8].

Developing countries suffer from a serious lack of infrastructure, especially in terms of refrigeration equipment as shown in figure 4 figures based on 2018 GCCA Global Cold Storage Capacity Report [10]. This lack leads to huge food losses that affect the availability, diversity and nutritional qualities of food in various ways. Thus, there is a crucial need for refrigeration in order to preserve qualitative and quantitative properties of food in most stages of the supply chain.

Figure 4:
Refrigerated warehouse capacity in m³ per urban resident (2018)



So, an increased use of refrigeration would allow developing countries to benefit from a larger quantity of better quality food.

This gap in refrigeration infrastructure has a significant impact on food availability and causes considerable losses, mainly in low-income countries, as shown in figures 5 and 6.

The new assessment of these losses by IIR shows that in 2013, **only 778 million tons of food were preserved by refrigeration in the world while theoretically, 1,661 million tons should have benefited from refrigeration** in order to avoid spoilage and losses. On that basis, losses due to a lack of refrigeration are estimated to be over 475 million tons in the world.

Which means that over 13 % of the food produced in the world is lost because of a lack of refrigeration, with high percentages in low-income countries that still lack an appropriate cold chain.

The assessment of losses due to a lack of refrigeration leads to the following results:

Figures 5 and 6 show that considerable amounts of food are lost due to a lack of refrigeration mostly in developing countries. More efforts are therefore needed to reduce the gap in the use of refrigeration around the world in order to reduce losses.

Data presented in figure 5 clearly prove the correlation between performant cold chains and low percentages of losses from processing up to consumption.

Figure 5:

Food losses due to a lack of refrigeration in the world (in 2013) (Mt) ^[8]

Year 2013	Million tons
World food production	3630 Mt
Food that should benefit from refrigeration	1661 Mt (46 % of the produced food)
Food that is actually refrigerated	778 Mt (47 % of food that should benefit from refrigeration)
Losses due to a lack of refrigeration	475 Mt (13 % of the produced food)

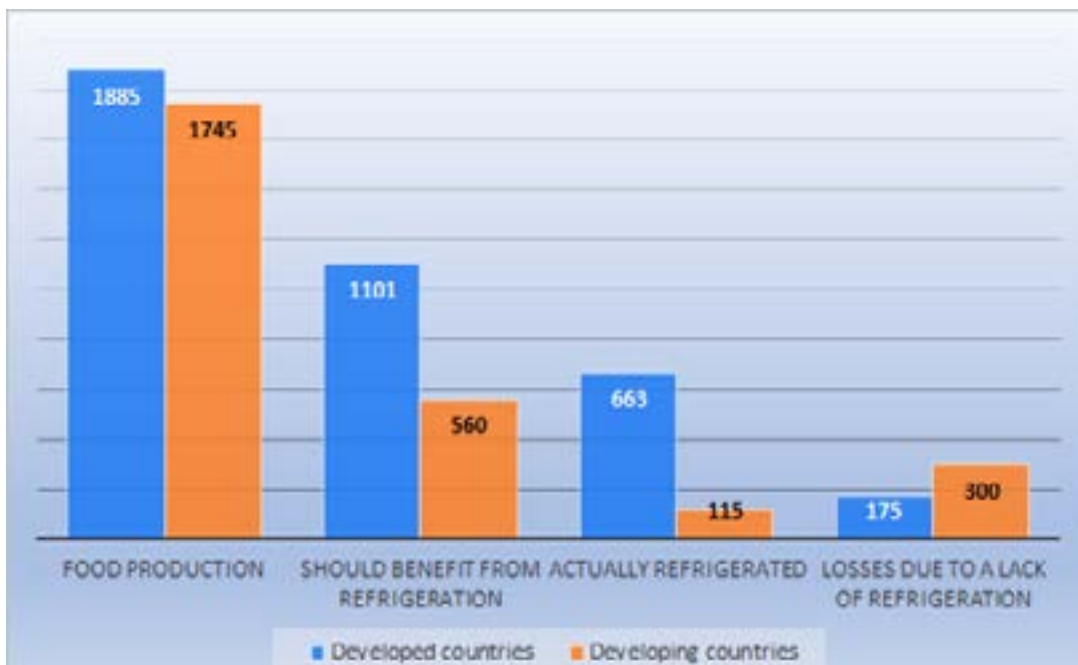
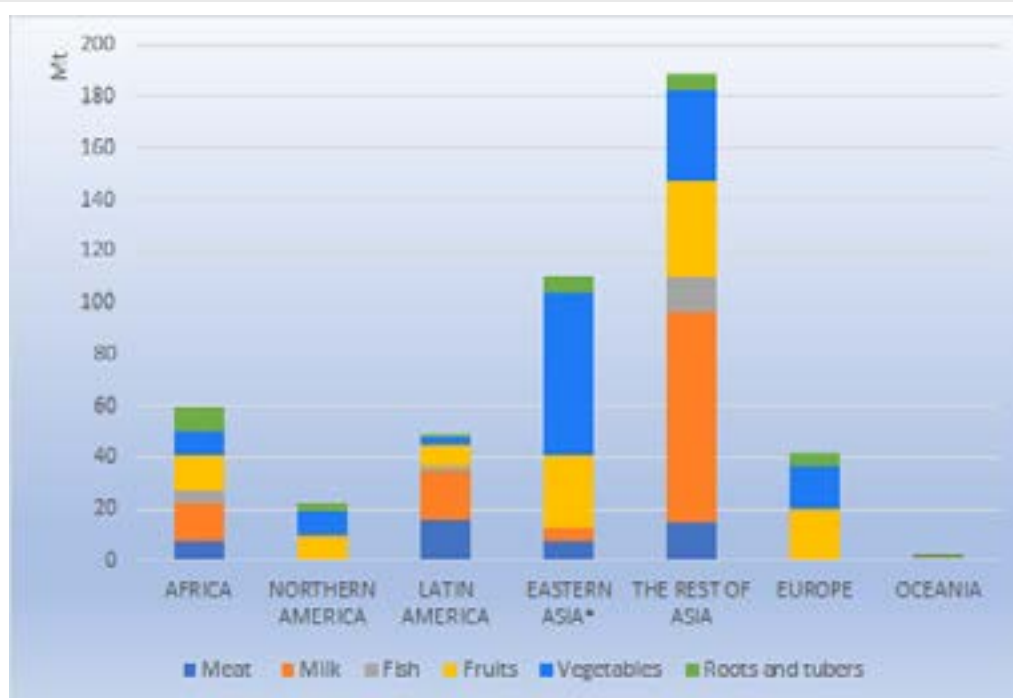


Figure 6:

Losses due to a lack of refrigeration per commodity (in 2013) (Mt) *



* Eastern Asia includes Japan, China, South Korea... For more details about this categorization of regions of the world see the document annex of this note [6]

So to what extent could improved cold chains help reduce undernourishment in the world ?

- **For developing countries: over 300 million tons of food is lost each year because of insufficient use of refrigeration**, which represents 63 % of world losses. This also means that for **1,745 million tons of produced food, 17.2 % is lost due to a lack of refrigeration**. These countries could save approximately 144 million tons of food if they acquired the same level of refrigerated equipment as developed nations. These food savings could boost food availability and safety and, as a consequence, reduce the number of undernourished people in these countries.
- For developed countries: food losses mainly occur at late stages of the supply chain because of wastage and also to breaks in the cold chain due to imperfect temperature management from distribution to consumption [11]. In these countries, corresponding food losses represent only 9.3 % but they could be further reduced thanks to better temperature management; according to a ReFED study [12] on possible solutions to food losses and waste in USA, 26 million dollars is the estimated annual profit of improving temperature management in the cold chain from farmers to retailers in USA. Thus, a better cold chain management in developed countries would enhance food safety and provide additional economic profit.

All in all, an improvement of the cold chain would save over 475 million tons of food that could theoretically feed 950 million inhabitants per year, and that is a sustainable way to improve food availability and quality without increasing the production. However, the improvement of the cold chain requires taking into account certain factors specific to the country or region concerned such as temperature, humidity, food consumption habits.

Reducing food losses and waste would not only improve food security, but it would also protect the environment from the impact of a significant part of greenhouse gases (GHG) emitted throughout the food supply chain. In fact, agricultural production is responsible for the emission of considerable amounts of greenhouse gases [13, 14], so reducing food losses by implementing additional efficient cold chains, especially in developing countries, would decrease corresponding GHG emissions. However, this also involves weighing this reduction in emissions against the additional GHG emissions from these additional cold chains. This issue will be discussed in details in an upcoming IIR informatory note related to the carbon footprint of food losses and the cold chain.

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IIR recommendations

Refrigeration can play a key role in improving worldwide nutrition by helping to preserve the quantitative and qualitative properties of perishable foods. The food that is traded on the international level and lost in some regions of the world can influence food availability, safety and prices in other regions.

Thus, it is essential to develop appropriate cold chains in low-income countries as a necessary first step to eradicate undernourishment in the world. Besides, a significant number of medical devices and products (vaccines...) are heat-sensitive, and thus also require an efficient cold chain ^[15]. There is no doubt that public concern about the importance of improving the cold chain has increased, but many measures still need to be taken to address the lack of cold chain infrastructures and the breaks compromising its integrity:

- priority must be given to the prevention of food losses and waste from early stages of production up to the final consumption, then the recycling and recovery solutions to tackle food losses that cannot be avoided. ^[7]
- raise awareness of decision-makers on the benefits of performant cold chains. ^[6]
- cooperation between the private and public sectors to define improvement and enhancement strategies.
- integration of performant, environmentally friendly and cost-effective refrigeration technologies in developing countries. ^[6]
- training engineers, technicians and users in order to set up, operate and maintain the refrigeration plants that make up these cold chains. ^[6]



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