Enabling food waste reduction in potential urban environments

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Food waste contributes to the consumption of increasingly scarce agricultural resources. It is thus desirable that food waste be minimized. Evolving urban lifestyles are often identified as a significant factor in the generation of food waste. Current patterns of food distribution and consumption result in increased wastage. An estimated 173 kg of food are wasted per person per year across the 28 European Union member states (EU-28), 70 percent of which are attributable to the stages of distribution, and to in-home and out-of-home consumption. A total of 62 million metric tons of food went to waste in the EU-28 in 2012 (Stenmarck et al.*, 2016), only a small percentage of which was recovered for recycling.*[1] *The difficulties of reducing food waste are exacerbated by the distance between agricultural production areas and population centers and by the heterogeneity of urban settings. Various actions intended either to reduce waste production at the source (prevention) or to increase the collection and recovery of organic waste (recycling) have been proposed and/or tested by both public (national or local authorities) and private (business or individuals) entities. Such actions variously involve technical, organizational, regulatory, or behavioral change, and are generally based on one or more of three underlying ideas:*

- *To optimize material and information flows through the use of new technologies;*
- *To recycle biomass (food and bio-waste) by optimizing the return of surplus food back to human or animal consumption, agriculture or industry;*
- *To foster new social practices and relationships that better prevent food loss and waste.*

The study summarized here suggests that particular attention be paid to the coherence between enablers of food waste reduction on one side, and policies focused on food safety and public and environmental health on the other side. It should be emphasized as well that actions favoring new value chains based on food waste recycling may work against the implementation of food waste reduction policies that address the origin of waste.

Box1 - Why focus on the city

Urbanization is a global trend: according to the UN, 75% of the population in industrialized countries now lives in urban areas, and two-thirds of the world's population will live in cities by 2050.

In developed countries, food waste mainly takes place at the distribution and consumption stages of the food chain (including in-home and out-of-home consumption): seventy percent of food waste produced in the 28 EU member-states comes from these two phases. Given urban concentration, this waste is produced primarily in cities.

Urban bio-waste is usually landfilled or incinerated; nutrient recycling for use in agriculture or livestock is relatively rare.

Cities are catalysts for social and technical innovation.

In order to identify and assess reduction strategies for urban food waste and to move toward the development of "zero waste" urban food systems, INRA joined with a group of international experts and carried out a study on waste reduction and food system optimization in a variety of urban environments.

These environments were understood in terms of urban space organization, material and information flows, and the role different actors can play in food waste reduction. Food systems were defined to include all stages of the supply chain from supplying to consumption, including the recycling of by-products and management of bio-waste. Wastewater treatment and management of other organic waste (garden waste) were excluded from the analysis.

Nine food waste reduction enablers adopted by various system actors (government agencies, institutions, business, and urban consumers) worldwide were identified. The nine enablers were then analyzed with regard to three potential future change scenarios relevant to urban environments in "developed" countries.

1. Stenmarck A., Jensen C., Quested T., Moates G. (2016). Estimation of food waste levels. FUSIONS EU project. www.eu-fusion.org

NINE REDUCTION ENABLERS FOR URBAN FOOD WASTE

Generic enablers for managing urban food flows and reducing waste were identified (cf. Box 2). These were then grouped into five categories:

• Economic or financial enablers (1)[2] are intended to regulate the flow of food products and bio-waste and/or to "internalize externalities." Different types of bonuses, fees, or taxes can be used to assign responsibility to various food system actors (households, restaurants, municipalities etc.) and thereby encourage the reduction and/or recycling of bio-waste.

• Normative enablers such as improving the flexibility of the operating standards adhered to by large-scale food distributors (2) so as to allow the sale of food items with cosmetic flaws, or adjusting policies with respect to sell-by dates (3) so as to keep food items that are close to their sell-by date within the human food supply (via discounting, on-site transformation, or as donation). An improved legal definition of the liability partitioning among different food system actors (4) or the assigning of responsibility to the consumer would facilitate some of these practices.

Box 2 - Methods for identifying and selecting enablers of food waste reduction

• Review and inventory of enablers suggested or implemented for food waste reduction worldwide;

• Categorizing of those enablers according to their relevance and universal character as judged by the international expert group;

• Selection of enablers based on an analysis of their likely effectiveness as well as their environmental and social consequences.

• Enablers related to town and city planning and the development of appropriate infrastructure (5) seek to encourage new urban practices amenable to the reduction of food waste. Such enablers can facilitate or formalize practices such as i) the sorting and collection of biomass for recycling, ii) urban agriculture (including livestock), and iii) new modes of consumption such as bartering, food sale by private people, street food, food courts, etc.

• Enablers making use of new technologies, particularly those relating to food product design, transformation, packing and logistics (6), are intended to help manage product flows or to control and extend product life. These include, for example, smart packaging, specially designed product indicators (RFID or radiofrequency identification, "freshness" buttons, systems to detect product alterations, etc.), non-thermal processes (e.g., electric pulse fields), minimal and gentle technologies such as fermentation, bio-protection of food products or food preparation areas, and "smart" household appliances.

Similarly, enablers for data sharing (7), product flow monitoring, and the use of smart sensors can make it possible to share key information (relating to production, inventory, sales, consumption) among all the actors along the supply chain so as to better manage and optimize food and bio-waste flows. Circular economy strategies use technologies to track the availability of surplus food and bio-waste for recycling (8), whether as feed, input for environmental bio-refineries, anaerobic digestion, energy production, composting or spreading.

• Finally, awareness raising, education and training (targeted at households, children, food business, restaurant and retail staff etc.) (9) are often advanced as a means of increasing individual responsibility and of training food system actors to minimize food waste and maximize bio-waste recycling.

2. Strategy number, e.g. (1) = strategy #1 – See Table, p. 6.

THREE CONTRASTING SCENARIOS FOR FUTURE URBAN AND SOCIAL CHANGE

The potential importance of each of these nine food waste reduction enablers, along with the obstacles they are likely to encounter, were assessed with regard to three contrasting scenarios for future change.
These virtual scenarios were developed by crossing the scenarios for future urban change described in Mora *et al* (2014)[3] with scenarios for future change in the social contexts of food systems.

Scenario 1: Large-scale management of unsold food items and food waste within a context of globalization and urban concentration

Continued urban growth in a context of globalization

In this scenario, further development of a globalized agro-industrial system, supported by monopolar urban centers, finds its effectiveness in terms of economies of scale and specialization. Lifestyles become increasingly uniform and individual, with weakened social bonds. Large- and medium-sized supermarkets and web retailers, operating a limited number of procurement hubs around large urban areas, leave little room for alternative or non-standard food networks. Eating out becomes increasingly important.

Considerable potential for waste

Food waste is considerable in this scenario as a result of consumers' disinterest in or mistrust of highly processed food, leading them toss it out in response to the slightest sign of alteration. Efforts to reduce waste at the source are limited, consisting primarily of the redistribution of surplus food via donation to food banks or other charities. Recycling of bio-waste is restricted to operators specialized in waste and wastewater management whose profits rely on the collection and treatment services rather than the return of bio-waste for use in agriculture.

Enablers for recycling bio-waste and increasing food donation

In this scenario, recycling of bio-waste from urban areas and institutionalization of donation to food banks are the food waste reduction enablers most likely to be implemented. Since opportunities for food waste recycling are of limited number at local level, bio-waste recycling takes place far from urban centers. To facilitate this process, citizens are encouraged (by means of financial and other incentives) to change their domestic habits and to carefully separate food waste from other waste.

Food waste prevention efforts are minimally developed and rely primarily on technological approaches, seeking to extend product life or improve the flow of information and supply chain management so as to achieve better match between supply and demand. The withdrawal of products from sale prior to their sell-by date becomes priority so as to facilitate donation to charitable associations. To support retailers' participation in these practices, food donors must be protected from legal liability.

Awareness raising, education and training to reduce food waste are focused on best practices for sorting bio-waste and for redistributing surplus food, and are promoted by government agencies, the waste management sector, neighborhood associations, schools, etc.

Scenario 2: Localized food chains supporting food waste reduction in a context of city networks and green growth

City networks and an expanding green economy

In this scenario, neighboring medium-sized cities forge cooperative interconnections, and the urban environment is transformed through the appearance of satellite towns and new urban hubs.

3. Mora O., Lançon F., Aubert F., de Lattre-Gasquet M. (2015). New urban-rural relationships to 2050: Impacts on land use and food security. Report of the Agrimonde-Terra workshop. Paris: INRA-Cirad, 64 pp.

This process is accompanied by increasing mobility of individuals, merchandise and information. Networks of medium-sized towns and cities establish new relationships with their hinterlands. Public authorities seek to promote circular economy and green growth, notably through the creation of multi-use spaces (e.g. eco-neighborhoods, eco-industrial parks) and by adopting regulatory and taxation policies favoring ecological transition and strengthening local economies.

Box 3 – Future change scenarios for the organization and social context of cities and food systems

Urban areas

Population concentration in mega-cities. Continued development of large urban areas, with a progressive homogenization of lifestyles across cities.

City networks. Medium-sized cities with closer ties to rural areas and significant endogenous growth. Networks develop with the appearance of new urban hubs.

Cities in decline in terms of population and/or governance. Large cities with a weak capacity to attract new residents, jobs, and services and to limit pollution and urban congestion, etc. Reduced role of public authorities.

Social contexts of food systems

Globalization. Agro-industrial system based on long supply chains characterized by a high level of specialization (industrial food processors, large-scale distribution and retailing, restaurant chains, bio-waste management, etc.).

Green growth. System relying on advanced technologies to facilitate recoupling of growth and wise resource management (industrial ecology, circular economy, eco-neighborhoods, etc.).

Local, social and inclusive economies. System based on solidarity and sharing, making use of close social networks, participatory economies, urban agriculture, barter, collective ownership of tools, etc.

A coordinated approach to reducing urban food waste

Eco-industrial parks associate production units operating in synergy with one another and with agricultural production areas. Weak economies of scale are compensated for by optimization in terms of material, water, and energy exchange. Projects centered around the establishment of environmental bio-refineries appear, supplied by urban bio-waste and other local biomass sources (from industrial, agricultural, or forestry activities). Facilitated by digital systems, relationships based on proximity and non-standard distribution networks multiply, responding to the diverse needs of consumers and making it possible to tightly match supply and demand. Consumers make use of smart devices to help reduce domestic food waste.

Strategies for cascading use of biomass and new urban practices

Close distance between consumption areas and intermediate spaces dedicated to food production and transformation or the recycling of bio-waste presents opportunities for efficient resource management. Fiscal mechanisms (incentives, fees, taxes) put in place by public authorities are critical to stimulating sorting and recycling of waste. Municipalities and local institutions implement zoning rules and offer material and financial support for infrastructure dedicated to closing loops in supply chains. Since bio-waste has market value, all food system actors give priority to smart recycling of surplus food, rendering food waste prevention secondary. Strategies such as withdrawal of products near their sell-by date and the revision of food product standard agreements are also less important.

Knowledge requirements for the implementation of key enablers for food waste reduction within three scenarios of future change (numbers refer to the nine enablers identified above).

People, citizen groups	Business	Public bodies (national and local authorities/institutions)	Knowledge requirements

Scenario 1 - Globalization and urban concentration

ENABLERS FOR... PREVENTION / RECYCLING/ RE-USE

People, citizen groups	Business	Public bodies (national and local authorities/institutions)	Knowledge requirements
	(7) Information and data sharing, monitoring of product flows (3) and (4) Withdrawal from sale of nearly-expired products for food donation (8) Off-site/centralized recycling of bio-wastes	(5) Logistics for recovery/ recycling (4) Exemption from liability for donors (good Samaritan law) (1) Financial mechanisms (incentives, fees, taxes, etc.) to encourage sorting and recycling of waste	• Identification, use and methods for information sharing among actors • Changing standards and perception of waste • Urban and regional metabolism: analysis of bio-geochemical cycles • Systematic approach to organizing biomass flows; ecological design for cities and adjacent regions
(9) Education & training			

Scenario 2 - City networks and green growth

ENABLERS FOR... PREVENTION / RECYCLING/ RE-USE

People, citizen groups	Business	Public bodies (national and local authorities/institutions)	Knowledge requirements
(5) Services (e.g. order and delivery, just-in-time manufacturing)	(6) Advanced food-processing and food-preservation technologies (7) Data analysis, sensors, monitoring of flows (5) Eco-parks, industrial symbiosis; periurban agriculture and livestock (8) Rural/urban bio-refineries; biogas production and anaerobic digestion	(1) Financial incentives to reduce waste (5) Logistics and planning to encourage eco-neighborhoods, eco-industrial parks, etc. (1) Financial incentives to favor sorting and recycling of bio-waste	• Management of food product shelf-life • Identification, use and methods for information sharing among actors • Environmental bio-refineries: economic models, facility size, input, etc. • Urban and regional metabolism: analysis of bio-geochemical cycles • Health risks linked to the exchange of materials and the accumulation of contaminants
(9) Education & training			

Scenario 3 - Cities in decline and sharing economies

ENABLERS FOR... PREVENTION / RECYCLING/ RE-USE

People, citizen groups	Business	Public bodies (national and local authorities/institutions)	Knowledge requirements
(5) Bartering of meals, collective food processing, gleaning, car-sharing for food transport, etc. (6) Gentle technologies for food processing and preservation (5) Urban agriculture and livestock (for domestic use), shared gardens (8) Neighborhood composting	(6) Gentle technologies for food processing and preservation (3) Withdrawal from sale of nearly-expired food products (discount, specialized brokers, on-site processing, etc.) (2) Increased flexibility within food product standard agreements (5) Urban agriculture and livestock (8) Biogas production/anaerobic digestion and domestic energy production	(5) Making urban infrastructure available for food production, logistics, and bio-waste management	• Changing standards and perception of waste • Zoning and urban planning, infrastructure • Risk of pathogen and contaminant spread
(9) Education & training			

Scenario 3 : Fighting food waste in the context of cities in decline and of the development of local, social and inclusive economies

Cities in decline

In this scenario, major urban centers are gradually abandoned as they become less attractive (due to congestion, pollution, lack of housing). Secondary centers become more important. Public institutions, heavily in debt, struggle to provide basic services. Local, social and inclusive economies and informal systems emerge.

Food system closed-loops rely on the development of the sharing economy

Food becomes a means for the formation of social connections, cohesion and solidarity both within the city and between the city and its peripheral production areas. Areas for food production (urban gardens) as well as for food processing and preservation are established in common. People invest time and energy and take over system activities (for example, food or bio-waste transports, meal preparation for delivery on demand, etc.). Fighting food waste becomes a priority in line with the objectives of social inclusion and improvement of a degraded urban environment. Citizen groups take steps to educate the public and build awareness to reduce waste.

Enablers organized around sharing and collective action

In this scenario, gentle technologies for food processing and preservation and for biomass recycling are implemented in conjunction with new forms of urban collaboration. Bio-waste generated at the neighborhood level (vegetable scraps, coffee grounds, non-edible food stuff etc.) is used in urban agriculture and livestock or to produce energy (small-scale anaerobic digestion units). Business, food processors, and distributors remove nearly-expired food products from sale for discounting, brokers or food preparation on-site. Commercial food product standards are modified to allow for sale of non-conforming items (size, cosmetic flaws, insufficient remaining shelf-life etc.), thereby developing a new market segment, since some customers do not bother about these criteria. Health risks are less of an issue; distributors are less fearful of the risk of assuming liability and are thus more ready to donate food. On the other hand, there is no funding available to provide financial incentives for waste prevention, sorting or reduction.

SOME ENABLERS ARE COMMON TO ALL THREE SCENARIOS, BUT REQUIRE DIFFERENT METHODS FOR IMPLEMENTATION

Although most food waste reduction enablers can be utilized within all three of the scenarios described here, methods for their implementation will vary strongly according to the specific urban environment. Thus, in an environment of continued urban concentration and globalization, closing loops in food systems will depend on the establishment of large-scale bio-waste processing facilities, whereas an environment of city networks and green growth will favor the emergence of medium-sized facilities located at logistical hubs ("rurban" bio-refineries or anaerobic digestion plants). The city in decline favors the development of the sharing economy and collective and socially inclusive approaches.

Implementation methods to encourage the recycling of food waste will likewise vary: their development will depend on industrial technologies in the case of globalization and continued urban expansion, whereas in the case of city networks and green growth, the recycling of bio-waste will be linked to the development of the circular economy, supported by urban planning and appropriate infrastructure as invested in by local institutions.

While awareness raising, education and training for improving recycling habits are relevant to all the scenarios described here, they may be used less often (due to a lack of resources) or be less necessary (since such practices will develop "spontaneously") in the environment of cities in decline and sharing economies.

Prior to food consumption, material flow optimization will rely on close distance in the two scenarios of city networks and cities in decline, though they make use of different technologies and mechanisms. In the case of city networks and green growth, system optimization will be facilitated by digitizing food system activities, connecting food system actors and exploiting data flows in order to improve logistics efficiency. In the environment of cities in decline and the sharing economy, implementation of gentle, inexpensive technologies and of rules for urban agriculture and other new food system practices (barter, meals on demand, etc.) are most likely to reduce food waste. Mechanisms such as revising commercial food product standards within large-scale distribution or those favoring food donation (shifting legal liability) can be used in all scenarios, but are most relevant in the case of globalization and continued urban growth.

Regardless of the urban environment, a twofold question presents itself. On the one hand, **enablers intended to source reduction of food waste must be consistent with food safety requirements, in the same way that risks linked to contaminant spread may act as a brake upon the use of bio-waste in agriculture, for energy production, chemical processes or as material for bio-products. On the other hand, enablers encouraging recycling of bio-waste may work against the primary declared objective of current public policy: food waste prevention through source reduction.**

This analysis of enablers of food waste reduction suggests that such efforts be considered in conjunction with other transformations subject to other factors, including the diversification of food systems, the development of circular economy, and the growth of participatory economies relying on informal systems. The strategies identified here should be reflected within this larger framework, demanding new knowledge and specific tools. In particular, an analysis of the arbitration and interactions among the many actors involved and the economics of the associated supply chains is needed. Strategies to reduce food waste can in this way achieve their greatest effectiveness.

Study organization

This study was conducted at the request of INRA's Scientific Director for Food & Bio-economy. It was directed and coordinated by Stéphane Guilbert (Montpellier-SupAgro) and Barbara Redlingshöfer (INRA), assisted by Mélanie Gracieux and Claire Fuentes. Support for the working group was provided by Céline Laisney and Véronique Lamblin (Alim-Avenir) and by Béla Czuppon (Les perles de verre).

Consisting of international scientific experts and stakeholders, the working group was committed to identifying enablers of food waste reduction, describing the urban and social environments, and analyzing the strength and relevance of the enablers within those environments. Working group members were: Jean-Claude André (CNRS), Christine Aubry (INRA), Christophe Bayle (SEMAPA), Nicolas Bricas (Cirad), Guy Debailleul (U. Laval, Canada), Sybil Derrible (U. of Illinois, USA), Hugo De Vries (INRA), Patrick Hervier (France Nature Environnement), François Jegou (Strategic Design Scenarios, Belgium), Amandine Lebreton (Fondation Nicolas Hulot), Loïc Leray (U. Lausanne, Switzerland), Blanche Lormeteau (U. Nantes), Jean-Michel Medoc (Cirad, Senegal), Olivier Mora (INRA), Jean-Luc Pujol (INRA), Christophe Soulard (INRA), Jean-Philippe Steyer (INRA), Marketa Supkova (International Urban Food Network), and Isabelle Touzard (Montpellier-Métropole).

The steering committee was Christine Cherbut, Paul Colonna, Catherine Esnouf, and Bertrand Schmitt.

To learn more :

Guilbert S., Redlingshöfer B., Gracieux M., Fuentes C., 2015. Systèmes alimentaires urbains: comment réduire les pertes et gaspillages alimentaires? Rapport d'étude, INRA (Paris), 45 pp.
Recueil de Nouvelles. Annexe au rapport d'étude, INRA: Paris, 34 pp.

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