Food Waste throughout the Food Production Continuum – Water Food and Energy Nexus

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SHORT ARTICLE

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ABSTRACT

This article addresses the inefficiencies in the food production system (aka continuum) within the nexus of food, energy, and water systems (FEWS). The food processing industry in the U.S. and worldwide, is responsible to excessive food waste. The processed foods continuum ranges from minimally processed and ready-to-eat items to complex preparations requiring packaging and controlled temperature storage. Food waste is a very complex issue that cannot be ignored because it is directly associated with serious challenges in food security and very negative impacts to the environment. The pressing need to produce more food at a lower cost to the environment by 2050 makes improvement of the farm-to-table processing stages both challenging and essential. Water and energy demands by the food processing industry are continuously increasing. Wastewater controls and best practices at the processing and post- consumption stages are highly effective in reducing the water footprint. Current efforts to reduce the food waste stream within the processing chain are minimal and clear benefits to food manufacturers are not well defined and almost non-existent. The food industry must get more involved with local and federal agencies to understand the impact of reduction strategies in the food waste stream. To efficiently feed humanity in 2050 and beyond, innovative technologies must be developed, and new societal norms must be adopted, that support food waste mitigation and management across all stages of the food processing continuum. These efforts should help improve access to nutritious food, lower energy-to-food ratios, and optimize the reduction of food waste streams.

Key Words: Food production; Food processing; Food waste; Food systems.

Introduction

The Food and Agriculture Organization [1] identified the four pillars of food security as availability, access, utilization, and stability. As more countries rely on specific commodities to provide the required nutrients and caloric intake, the availability of food supplies is threatened [2]. As diversification of crops and other commodities are necessary to ensure food security worldwide, within the nexus of food, energy, and water systems (FEWS), mitigating and managing material waste is a crucial factor in fostering food security, improving resource efficiency and reducing environmental impacts.

Food systems are often defined along a farm-to-table (aka field-to-fork) continuum. Yet, more sustainable and resilient food systems may need to consider resource inputs and outputs from soil-to-soil, akin to the cradle-to-cradle model in progressive industrial systems. Managing food systems as a cyclical flow of natural resources, within human-scale spatial and temporal domains, can support innovations in food waste mitigation and management. Generally, a cyclical food system is divided into five interconnected stages: (1) agricultural production; (2) processing and manufacturing; (3) transportation, storage, distribution and marketing; (4) consumption at home or foodservice operations; and (5) post-consumption waste diversion and conversion.

Engendering equality and security in food systems and services are two of the biggest challenges facing humanity. Concerns about the quantity and quality of energy and water supplies amplify these problems as food systems are natural resource intensive. Furthermore, a growing global population needs more effective strategies for reducing food waste and minimizing water and energy consumption at various stages across food systems. In this article, the concept of food waste refers to inefficiencies or underutilization of material resources across any stage of a food system. This article addresses common challenges to food waste throughout the FEWS nexus and highlights a selection of potential solutions.

Food Waste Challenges Throughout the Food System

By some estimates, food production may need to be doubled by 2050 in order to satisfy the needs of a world population projected to grow to more than nine billion. [3] However, other perspectives suggest humanity already produces enough food to feed not only those billion humans in hunger today, but additional billions yet to be born [4]. Thus, poverty, inequality, and misallocated resources are also factors of food system waste all-too-often overlooked. Additionally, approximately 1.3 billion tons of foods are wasted every year worldwide [5], further supporting the need for understanding and improving the relationships between food supplies and demands.

In the United States (U.S.), 40 percent of edible food is sent to landfills or remains unharvested at farms [6-8], while 80 percent of the waste comes from perishable foods. Several potential causes for, and indicators of, wasteful food systems have been evaluated [8, 9]. The U.S. food system uses more than 50 percent of arable land, 80 percent of freshwater and 10 percent of the total energy budget [5, 8-10].

Overcoming the food security challenge is difficult because 'more food must be produced at a lower environmental cost in a resource constrained environment' [3, 11-13]. Thus, monitoring, measuring, and modeling the connections among the food, energy, and water sectors using a 'nexus' approach is necessary to understand the challenges and empower practical solutions [14]. Strategies that pay attention to the food waste across the FEWS nexus should aim to also support more universal access to abundant nutritious, safe food products that ensure healthy diet habits and alleviate hunger while mitigating the negative environmental impacts of the five stages of food systems [15].

Challenges and Potential Solutions

Food Waste and the Environment

Food waste has negative environmental impacts, most prominently the increase of greenhouse gas emissions (CO_2, methane, and nitrogen-based compounds) as food decomposes [14]. In response, the U.S, Environmental Protection Agency and U.S. Department of Agriculture have established a national goal to halve food waste by 2030 [5, 9, 16, 17]. Strategies to reduce food waste will diminish its impact on the environment including implementation of composting and recycling programs to reduce greenhouse gas emissions, use of new and more recyclable materials in the packaging of foods, and more efficient disposal and materials management methodologies (USEPA, 2015).

Food Waste and Water Use

Water use in food systems is a pressing issue as demands for water will continue to increase as food production targets increase. Though local conditions will vary, climate change is likely to limit access to freshwater sources, increase drought conditions and water pollution, affect harvest yields, and decrease land productivity [3]. Strategies to reduce wasteful water use at the production stage of a food system include changes in irrigation methods to provide more crop per drop [3], adoption of practices that reduce water use such as no-till agriculture, and precision farming. Effective and safe on-farm storage practices may further reduce food loss and waste. The food processing industry is one of the largest consumers of energy and water because, in the food processing plant, water is used as an ingredient in raw or finished foods, in production, or as an industrial utility [18]. There are opportunities to reduce water usage at this stage by means of careful water-reduction policies, plans, and enforcement of emerging technologies that reduce water consumption and improve water reuse. Wastewater controls and best practices at the processing and post-consumption stages are highly effective in reducing the water footprint [19-21].

Food Waste and Energy Consumption

U.S. food systems energy consumption is mostly used for refrigeration, cooking, heating, sterilizing and motor-driven systems such as conveyors and other equipment [22]. However, the high energy-to-food ratio of 10:1 is often overlooked [23]. This problem of the FEWS nexus has historically been addressed with energy efficiency and fuel switching initiatives such as alternative and renewable energy sources, conversion of agricultural waste into power and increased used of biofuels [23-25]; [14]. Emerging technologies such as high-pressure processing, pulse and electric fields, microwave, ultrasound and infrared heating and drying have the potential to reduce energy usage in food processing plants.

Food Waste Management

Efforts to minimize food waste in service industries, institutions, schools, and homes mainly focus on measures to decrease and divert the amount of solid waste that would typically be landfilled. Several programs are already in place to divert 'ugly' foods from the waste stream to foodservice facilities around the world including the U.S. In the U.S., some states offer tax credit for donations of wholesome food to food banks. However, these efforts are currently minimal and there is need to clearly describe the benefits of these tax incentives to the food manufacturers. The food industry needs to get more involved with local and federal agencies to understand the impact of these reduction strategies in the food waste stream. Waste management categorization methods have proven useful at the production stages and further analysis must be carried out at the processing and consumption stages.

Food Waste and Human Behavior

Consumers account for 21 percent of food loss and waste in the U.S. Unified education efforts directed at consumer food purchasing and eating behaviors, as well as portion size offerings in foodservice facilities, must be implemented to create a systemic transformation in consumer and food business employee awareness of their roles in the amount of food waste produced [26-30] [8]. Consumer education is highly cost-effective and critical to the overall success of food waste reduction strategies. Other strategies include increasing consumer awareness on the effect of household storage, preparation and disposal on food waste.

Conclusions

To efficiently and equitably feed humanity in 2050 and beyond, innovative technologies must be developed, and new societal norms must be adopted, that support food waste mitigation and management across all stages of current food systems. Heating, cooking and drying technologies to reduce energy usage in the processing stages of the food production continuum are being evaluated but have not been fully adopted. Likewise, technologies to treat and reuse water should be explored in terms of their potential to reduce water usage. Effective waste management methods that characterize the type and amounts of food waste at every stage of the food production continuum must be developed, evaluated, and implemented.

Novel decision-support is necessary to prompt constructive changes in public and private sector policies and practices, as well as consumer behaviors toward food. Global initiatives to implement comprehensive food waste diversion and conversion programs may support integrated solutions to maximize the economic, social, and environmental benefits possible from more cyclical food systems. These benefits may include improved household access to nutritious food, lower energy-to-food ratios, and the reduction, reuse, or recycling of food waste streams. Such interventions should reduce food losses and waste while increasing human health.

References

1. FAO. Declaration of the World Summit on Food Security. Food and Agriculture Organization of the United Nations, Rome, Italy. 2009a.
2. Khoury, C.K., Bjorkman, A.D., Dempewolf, H., Ramirez-Villegas, J., Guarino, L., et al; (2014). Increasing homogeneity in global food supplies and the implications for food security. Proc. Natl. Acad. Sci USA, 2014. 111(11): p. 4001-4006.
3. Webber, M, More Food, Less Energy. Scientific American, January, 2012. P. 74-79.
4. Holt-Giménez, E., Shattuck, A, Altieri, M., Herren, H. and Gliessman, S, We Already Grow Enough Food for 10 Billion People … and Still Can't End Hunger. Journal of Sustainable Agriculture. 2013. 36(6): p. 595–598.
5. FAO. Global food losses and food waste. Extent, causes and prevention. Food and Agriculture Organization of the United Nations. Rome, Italy. 2011.
6. Gunders, A, Wasted: How America is Losing Up to 40 percent of Its Food from Farm to Fork to Landfill. NRDC (Natural Resources Defense Council) Issue Paper 2012, p. 1-16.
7. Reich, A.H and Foley, J.A, Food Loss and Waste in the US: The Science behind the Supply Chain. Food Policy Research Center, University of Minnesota, 2 pages. 2014.
8. ReFED. A Roadmap to Reduce U.S. Food Waste by 20 Percent. Rethinking Food Waste through Economics and Data. 91 pages. 2016.
9. FAO. Food for Cities. Food and Agriculture Organization of the United Nations. Rome, Italy. 2016.
10. Chang, Y., Li, G., Yao, Y., Zhang, L. and Yu, C, Quantifying the water-energy-food nexus: Current status and trends. Energies, 2017. 9: p. 65-82.
11. FAO. FAO's Director-General on How to Feed the World in 2050; Food and Agriculture Organization of the United Nations: Rome, Italy, 2009b. p. 837–839.
12. TGOS. Foresight. The Future of Food and Farming. The Government Office for Science: London, UK. 2011.
13. De Laurentis, V., Hunt, D.V.L. and Rogers, C.D.F, Overcoming food security challenges within an energy/water/food nexus (EWFN) approach. Sustainability, 2016. 9: p. 95-118.
14. Castell-Perez, M.E, Gomes, C, Tahtouh, J, Moreira, R, McLamore, E.S, Knowles, H.S. III, Food Processing and Waste within the Nexus Framework. Current Sustainable/Renewable Energy reports, 2017. 4(3): p. 99-108.
15. Garcia-Garcia, G., Woolley, E., Rahimifard, S., Colwill, J., White, R. and Needham, L, A methodology for sustainable management of food waste. Waste and Biomass Valorization, 2017. 8(6): p. 2209-2227.
16. USEPA. Municipal solid waste generation, recycling and disposal in the United States: Facts and figures for 2012. United States Environmental Protection Agency, Solid Waste and Emergency Response (5306P) EPA-530-F-14-001, February, 2014.
17. IFPRI. Global Food Policy Report. International Food Policy Research Report. Washington, DC, USA. 2016.
18. Compton, M., Willis, S., Rezaie, B. and Humes, K, Food processing industry energy and water consumption in the Pacific northwest. Innovative Food Science and Emerging Technologies, 2018. 47: p. 371-383.

19. Hall, K.D., Guo, J., Dore, M. and Chow, C.C, The Progressive Increase of Food Waste in America and Its Environmental Impact. PLoS ONE, 2009. 4(11): p. e7940-e7945.

20. Schug, D, Reducing water usage in food and beverage processing. Food Engineering, April. 2016.

21. Wright Process Systems. California Water reduction Initiatives Impacting Food Manufacturers. Overview of Current Conditions. Systems White Paper, 8 pages. 2017.

22. Higgins, C, Reducing Food Processing Plant's Energy Costs. Power Transmission Engineering, 2016. P. 28-30.

23. Webber, M. How to make the food system more energy Efficient. Scientific American, December 29. 2011.

24. FAO, Energy-Smart Food at FAO: An Overview. Food and Agriculture Organization of the United Nations, 2012: Rome, Italy. 2012.

25. Van Dyk, R.Gama, D. Morrison, S. Swart, and B.I.Pletschken, Food processing waste: Problems, current management and prospects for utilization of the lignocellulose component through enzyme synergistic degradation. Renewable and Sustainable Energy Reviews, 2013. 26: p. 521-531.

26. WRAP. Household food and drink waste in the united kingdom. executive summary. Waste and Resources Action Programme, UK, 17 pages. 2013.

27. EPA. Industrial food processing waste analyses. U.S. Environmental protection Agency. Office of resource Conservation and Recovery, 11 pages. 2012.

28. EPA. (2019). Sustainable Management of Food. EPA Food Recovery Challenge.

20.

29. FAO. Food wastage footprint. impact on natural resources. Summary report. Food and Agriculture Organization of the United Nations: Rome, Italy, 61 pages. 2013.

30. USDA. The U.S. Food Loss and Waste Challenge. USDA. 2016.

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