Farm to Fork: Fritter overlooked and its impacts

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Abstract

Given the recognition of the major environmental implications of food wastage, relatively few studies have examined the impact of global food wastage from an environmental perspective. This is quite surprising as forecasts suggest that food production must increase significantly to meet future global demand. The objective of this study is to develop a sensible but simplified and transparent representation of the global food supply chain system to explore leverage point of intervention to reduce food wastage and its consequent GHG emissions. The results suggest that if the current fraction of food wastage across the supply chain remains unchanged, 20 percent of food produced for the purpose of human consumption will go waste. This waste is estimated to contribute to approximately 1.81 billion tons $C0_2$ equivalent by 2040, all things equal. The economic valuation of food waste is estimated at 1.4 trillion US dollars by 2040. Under the gradual reduction in food waste scenario, the model results suggest that intervention at the production stage has greatest impact in reducing food waste, total emission from food waste, cost associated with food waste and land under cultivation for food waste.

1. Introduction

World population is expected to grow by over a third, or 2.3 billion people, between 2009 and 2050 (UN, 2004). This is a much slower rate of growth than the one seen in the past four decades during which it grew by 3.3 billion, or more than 90 percent. Nearly all of this growth is forecast to take place in the developing countries. Urbanization is foreseen to continue at an accelerating pace with urban population to account for 70 percent of world population in 2050 (up from 49 percent at present) and rural population, after peaking sometime in the next decade, actually declining. At the same time, per capita income in 2050 are projected to be a multiple of today's levels. Relative inequality in per capita income is projected to be reduced considerably by 2050. However, absolute differences would remain pronounced and could even increase further, given the current huge gaps in absolute per capita incomes.

This trend means that market demand for food would continue to grow. Demand for cereals, for both food and animal feed uses, is projected to reach some 3 billion tones by 2050, up from today's nearly 2.1 billion tones. The advent of biofuels has the potential to change some of the projected trends and cause world demand to be higher, depending mainly on energy prices and government policies. The demand for other food products that are more responsive to higher incomes in the developing countries (such as livestock and dairy product, vegetable oils) will grow much faster than that for cereals. The projection show that feeding a world population of 9.1 billion people in 2050 would require raising overall food production by some 70 percent between 2007 and 2050 (Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., and Meybeck, A., 2011).

However, according to FAO, each year approximately one-third of all food produced for human consumption in the world is lost or wasted (FAO, 2014). The global volume of food wastage is estimated to be 1.6 Gtones of "primary product equivalents", while the total wastage for edible part of food is 1.3

Gtones (FAO, 2014). The issue of food wastage is of high importance in the effort to combat hunger, raise income and improve food security in the world's poorest countries. Food wastage have an impact on food security for poor people, on food quality and safety, on economic development and on the environment (Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., and Meybeck, A., 2011; Parfitt, J., Barthel, M., and Macnaughton, S., 2010). Food wastage represents a loss of resources used in production such as land, water, energy and inputs. Producing food that will not be consumed leads to unnecessary CO_2 emissions in addition to loss of economic value of the food produced. Economically avoidable food wastage has a direct and negative impact on the income of both farmers and consumers (Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., and Meybeck, A., 2011; Kumar Venkat, 2011). A reduction of food wastage could have an immediate and significant impact on their livelihoods. Improving the efficiency of the food supply chain by cutting food wastage could help bring down the cost of food to the consumer and thus increase access.

Given the wide recognition of the major environmental implications of food wastage, relatively few studies have examined the impact of global food wastage from an environmental perspective. This is quite surprising as forecasts suggest that food production must increase significantly to meet future global demand. Insufficient attention appears to be paid to current global food supply chain losses which are quite substantial and could go a long way to reduce global food demand. The objective of this study is to develop a sensible but simplified representation of the global food supply chain system to explore leverage point of intervention to reduce food wastage. Along with introduction in this section, we organize rest of the paper in the following manner. Section 2 presents the model structure. Section 3 describes the data, its source and presents the parameter estimates. Section 4 provides the policy scenarios and section 5 presents the results and their discussion. We provide references at the end.

2. Model structure

We use the five stages of food supply chain introduced by FAO report (FAO, 2014) to develop a simulation model using System Dynamics method (Sterman, J.D., 2000; Forrester J.W., 1961) in Vensim® software. We use the highest aggregate i.e. world and all food types for this initial version of our model. Based on the feedback of the conference participants, we will improve the model structure and will develop it for the seven regions and eight food commodity types. As we are considering world level, net international trade should be zero (imports-exports=0). As such, we do not model import/export. This may have some limitations but it will not compromise the basic objective of the model.

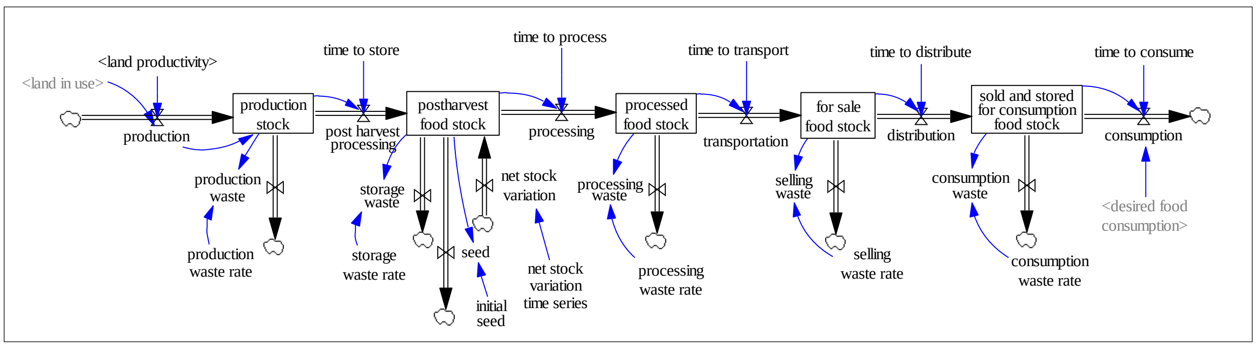


Figure 1: Model Structure

We consider the total land area available comprising of only two types: land in use for agriculture purposes including pastures and other land. The demand for food will initiate the conversion of other land into land in use. To model the food production, we first estimate the *'initial desired pc food consumption'* which is actual per capita consumption in 1961 from the FAO data. We assume that food consumption is a function of income for which we use GDP as a proxy to calculate *'desired pc food consumption'*. This *'desired pc food consumption'* is multiplied by *'population'* to give us *'desired food consumption'* which is divided by *'land productivity'* and gives *'desired land in use'* to determine land conversion. We observe that technological advancement over time has improved the productivity of the land and the produce. We have combined the two in land productivity. We present the Land Use module in Figure 2.

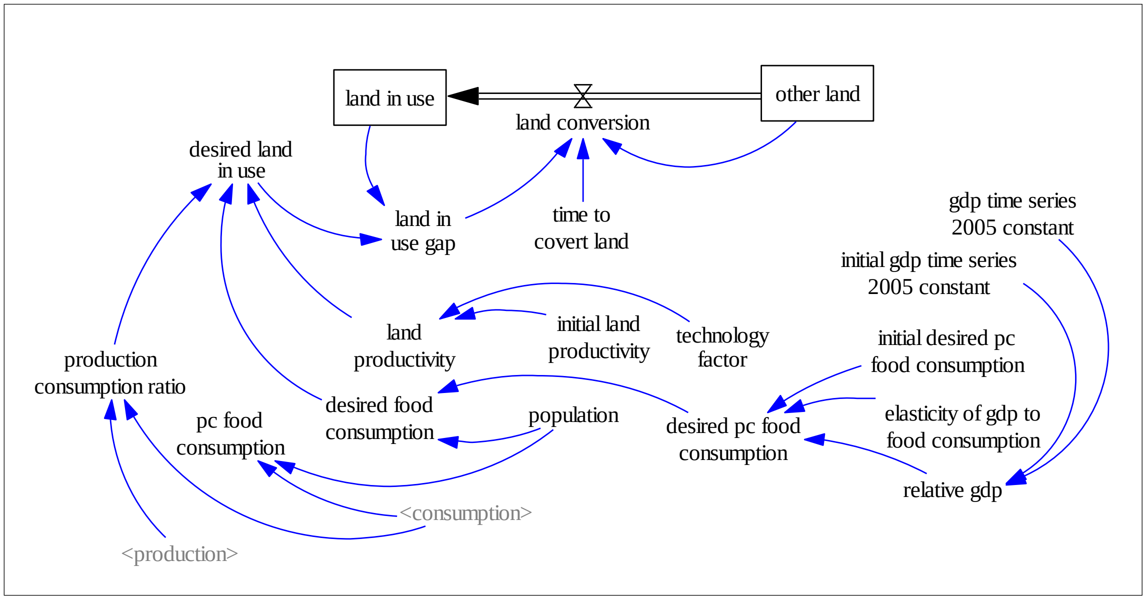


Figure 2: Land Use

Using different variables in the model, we formulate a number of different variables of interest. We present these in Figure 3.

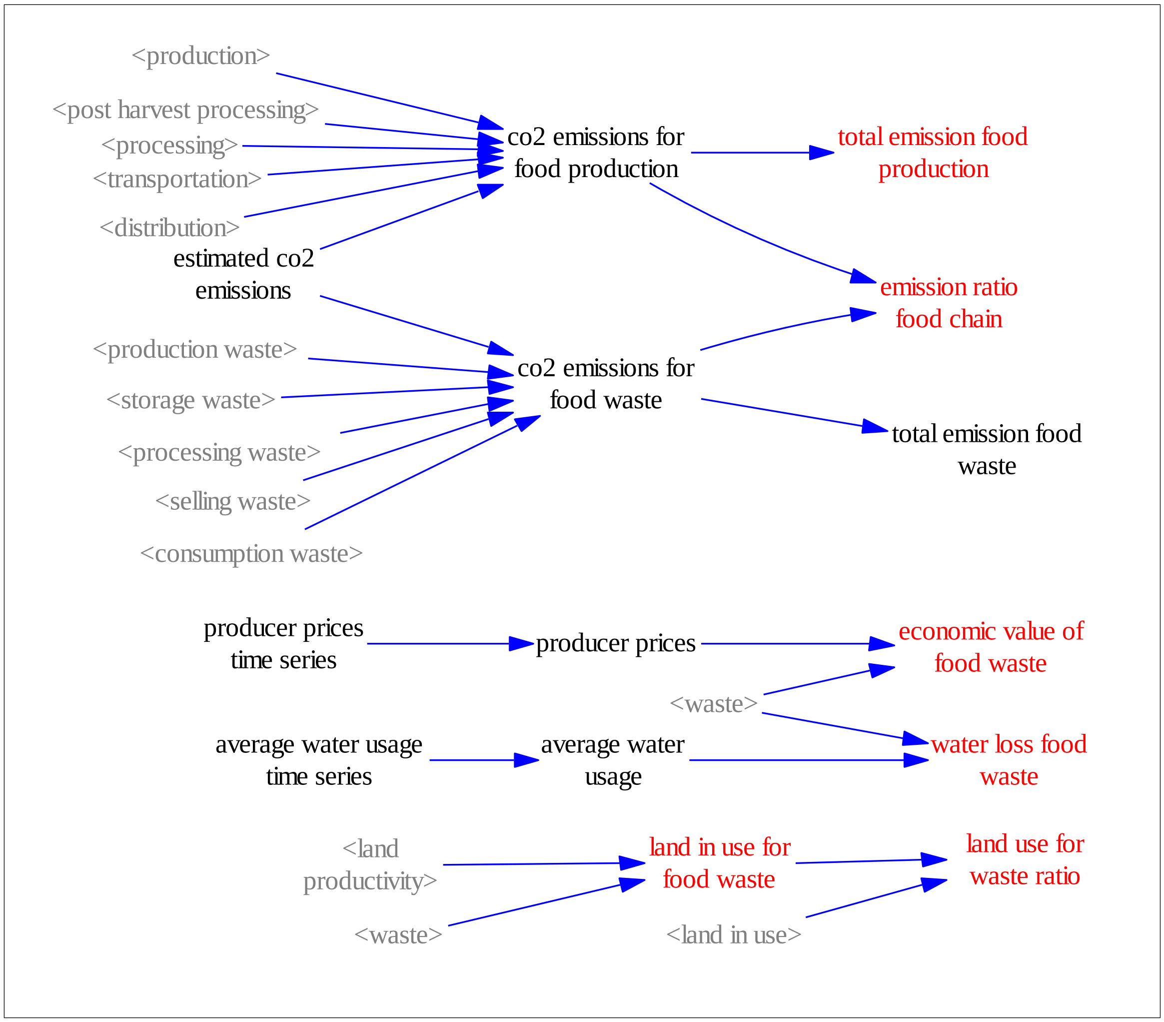


Figure 3: Variables of interest

3. Data sources, parameter estimation and model calibration

We use database of FAO to get the data about population, land, production, consumption, net stock variation, seed and waste. We estimate waste rates and emission at each stage from FAO report. Given these inputs, we estimate the remaining model parameters by using optimization feature of Vensim®. Using the estimated parameters we simulate the model and find that the model mimics the data.

4. Policy Scenarios

In addition to the base-case scenario in which current food wastage percentage across the food supply chain remains unchanged, we simulated an 80 percent gradual decrease in food wastage across the food supply chain by 2040. This scenario assumes that any gain in reducing food wastage is translated into food production decrease with a 2 year delay. This scenario is implemented from year 2015, where s1 is production waste scenario, s2 is postharvest waste scenario, s3 is processing waste scenario, s4 is sales waste scenario and s5 is consumption waste scenario. This policy scenario explores leverage points in the food supply chain to reduce food wastage and subsequently, CO_2 emission from food wastage.

5. Results and their discussion

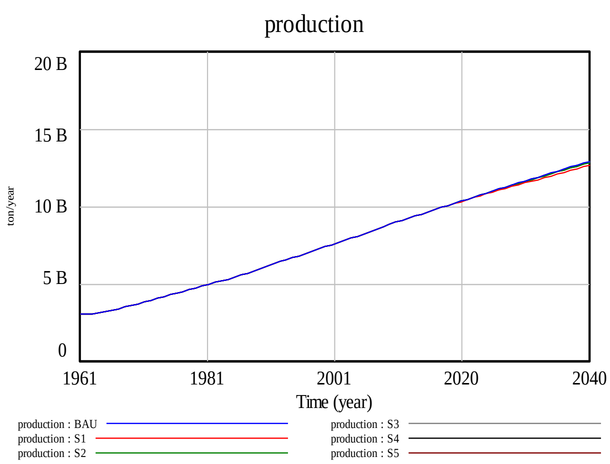
Under the base-case scenario, from 2010 to 2040, the quantity of food produced for consumption in the world is projected to increase from 8.98 billion tons to 12.9 billion tons, representing 44 percent increase. Of these 12.9 billion tons of food produced, it is projected that about 76 percent will be consumed by 2040 (which is approximately 9.85 billion tons). Food wastage is projected to increase from 1.84 billion tons in 2010 to 2.68 billion tons, representing 20 percent of food produced. Consequently, total $C0_2$ emission from food waste is projected to rise from 1.25 billion ton $C0_2$ equivalent in 2010 to 1.81 billion tons $C0_2$ equivalent in 2040, which is 45 percent increase in $C0_2$ emission from food wastage.

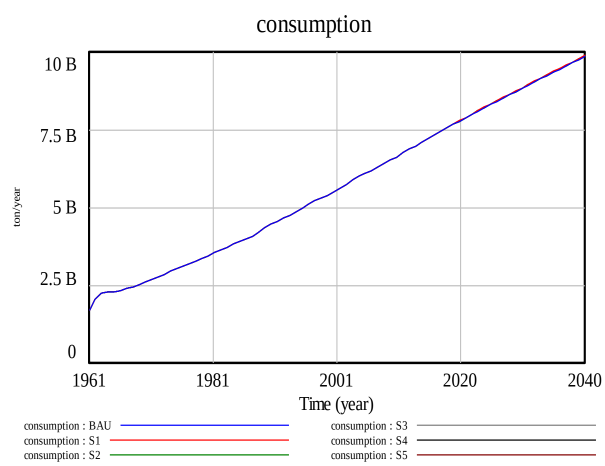
Further analysis of the base-case scenario indicates that production waste is the main contributor to food wastage in across the food supply chain. Thus, production food waste is projected to account for about 58 percent of total food wastage. However, storage, processing, selling and consumption food waste are projected to account for 16, 8, 7 and 11 percent of total food wastage, respectively.

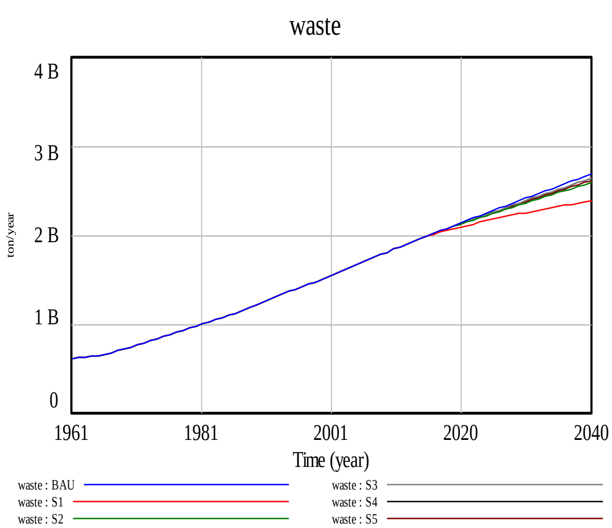
The economic value of food wastage, under the base-case scenario is estimated to rise from approximately 804 billion US dollars in 2010 to 1.4 trillion US dollars by 2040 under current valuation.

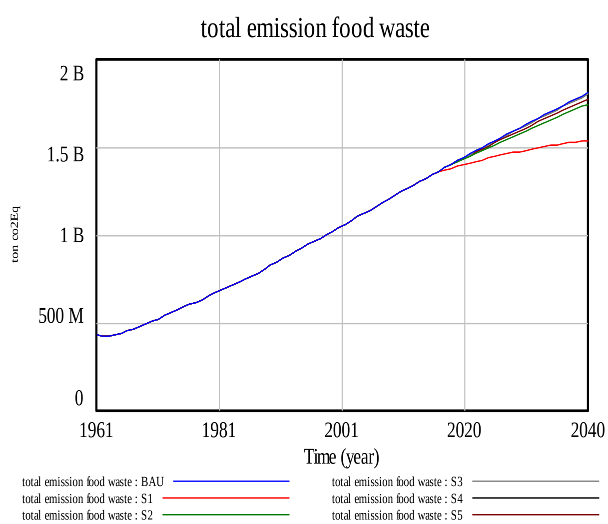
On the other hand, from 2010 to 2040, land in use for total food wastage is projected to decrease from 903,000 hectares in 2010 to 685,000 hectares in 2040.

Under the gradual decrease in food wastage scenario, by 2040, food production is projected to decrease by only 3 percent, relative to the base-case scenario, when production waste decline from 30 percent in 2015 to 80 percent by 2040. While postharvest and consumption wastes decrease food production by only 1 percent, respectively, that of processing and sales wastes is projected to have no impact on food production. On consumption, the gradual decrease in food waste scenario across the food supply chain had no impact on decreasing consumption.









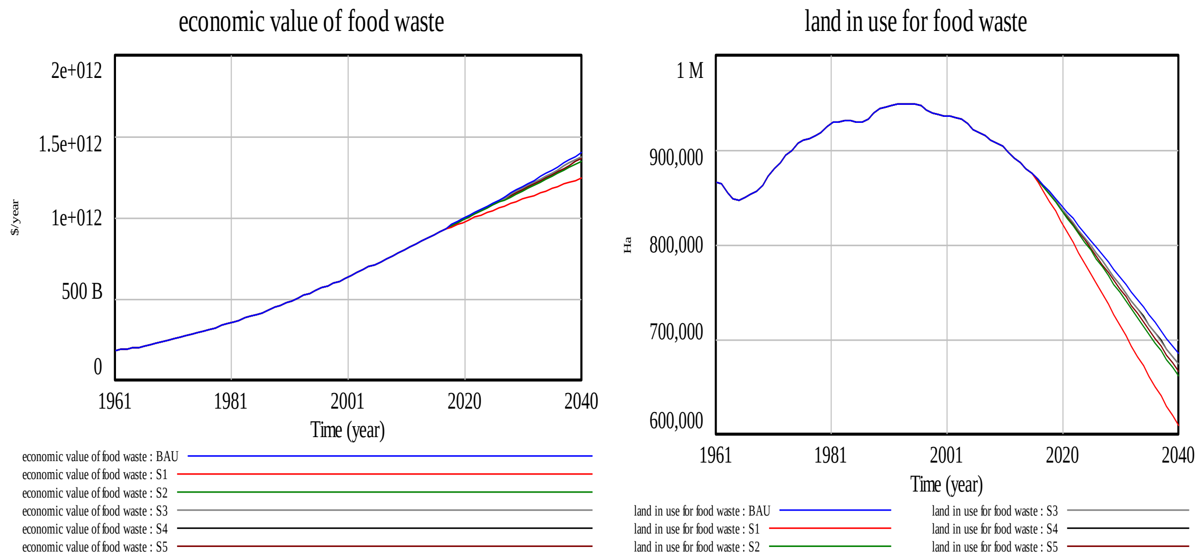


Figure 4. Simulation results

On food wastage, scenario s1 is projected to decrease food wastage by 16 percent compared to the base-case scenario, while that of s2 is projected to be 5 percent by 2040. The projected reduction in food wastage from s3, s4 and s5 are 2, 2, and 4 percentage point respectively. For total emission from food wastage, s1 is projected to reduce co_2 emission from food wastage by 22 percent, whereas, that of s2 is projected to be only 5 percent. Moreover, s3 is projected to reduce co_2 emission from food wastage by only 1 percent, while that of s4 and s5 are 0 and 3 percent, respectively. Likewise, on the economic impact of reducing food wastage, it is projected that s1 will reduce cost associated with food wastage by 19 percent relative to the base-case scenario. For s2, s3, s4 and s5, the projected estimates are 6, 3, 3 and 5 percentage points, respectively. Lastly, the impact of the scenarios on land indicates that s1, s2, s3, s4 and s5 is projected to decrease the quantity of land in use for food waste by 9, 3, 1, 1 and 2 percentage points, respectively.

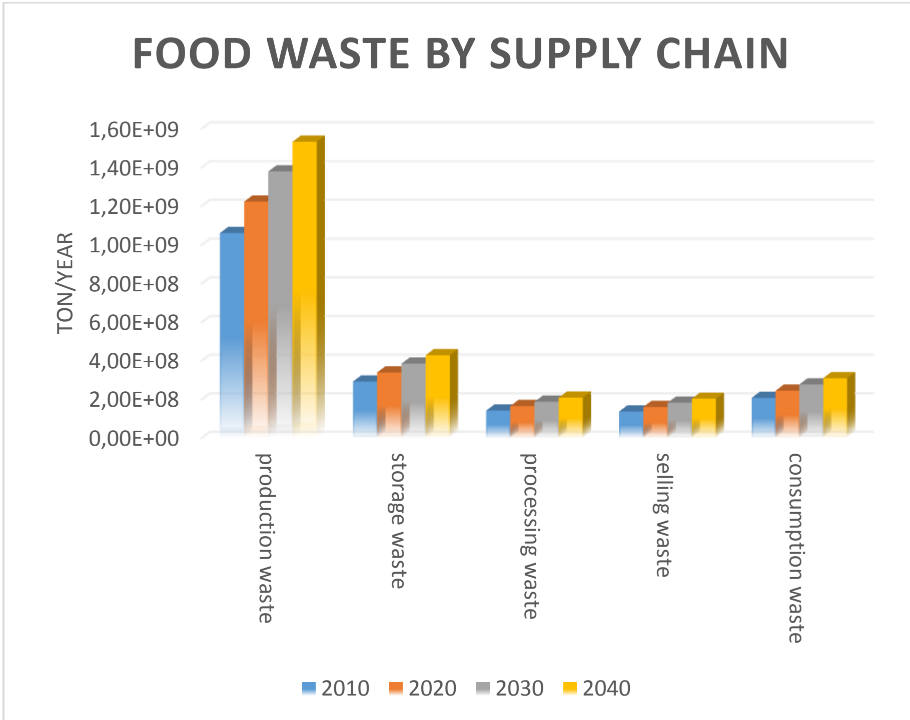


Figure 5: Food waste in food supply chain

The food supply chain consists of multiple interconnected stages or components contributing to the observed significant quantity of food wastage. As demonstrated in this study, the simplified model of the food supply chain demonstrates that if the current fraction of food wastage across the supply chain remains unchanged, it is projected that 20 percent of food produced for the purpose of human consumption will go waste. This waste is estimated to contribute to approximately 1.81 billion tons C02 equivalent by 2040, all things equal. The economic valuation of food waste is estimated at 1.4 trillion US dollars by 2040, under current valuation. Under the gradual reduction in food waste scenario, the model results suggest that intervention at the production stage has greatest impact in reducing food wastage, total emission from food wastage, cost associated with food wastage and land under cultivation for food wastage.

The simulation results can be explained by the interaction between demand and supply of food. Food demand is assumed herein as the quantity of food made available for human consumption, whereas food supply is presumed to be food production. As demand for food increases (i.e. consumption) increases due to population increase and a rise in desired per capita food consumption, food supply (i.e. food production) increases with a delay to meet demand, accounting for the expected food wastage across the food supply chain. The increase in food production as indicated in the model is due to a rise in desired consumption, which is as a result of population increase and a rise in desired per capita food consumption as income per capita rise. As more food is produced to meet demand, total food wastage increase in proportion to food produced. As suggested earlier, production waste account for about 58 percent of total food wastage, because it is estimated that about 30 percent of food produced is wasted before the postharvest stage of the food supply chain. Moreover, the observed decline in land in use for food waste is due to assumed significant increase in land productivity. Thus, as land productivity increases, lesser amount of land is required to produce a given quantity of food.

The key study finding, that any food wastage reduction policy that focuses the intervention at the production stage of the supply chain is likely to have significant impact on total food wastage and emission from food wastage, has policy implications. Overall, this finding suggests that if policymakers place more emphasis on any stage of the food supply chain other than the production stage, they are likely to make insignificant impact in reducing food waste and more so its impact on the environment as we know it. Policy makers must be proactive in responding to the needs of farmers who are likely to be the immediate beneficiaries of reducing food wastage at the production stage, but eventually the whole humanity will benefit at the downstream from improved environment with less $C0_2$ emission and its consequent effect on health, disasters and eventually on rain patterns for food production.

6. Conclusion and policy implications

This paper provides clear explain to why it is beneficial to invest in reducing food wastage at the production stage. This is important to understand because, if policymakers choose to focus their attention on other stages of the food supply chain, they are likely to have very limited success compared to what would have been at the production stage. In the light of this results, it is important to understand the impact of rising income on food demand and more importantly how low carbon innovative technology could be deployed to reduce the carbon footprint of the food supply chain.

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