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# Climate Change and Food Security: Highlighting Urban Food System and Regional Specificities

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## *1. Background*

Food security is an outcome of food system (Mbow and others, 2019). According to the Food and Agricultural Organization (FAO) (2001), situation of food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Thus, food security consists of four pillars: availability, access, utilization and stability. Food system needs to provide desirable out-comes to all these four pillars to ensure food security.

Currently, food system is broken (Schmidt-Traub and others, 2019) and unable to ensure food security for all the population although more than enough food is produced. Additionally, the current food system is also contributing to climate change and other environmental problems. Globally, 821 million people are suffering from hunger and undernourishment and around 2 billion adults are facing overweight or obesity (FAO and others, 2018). The global food system is contributing to 21-37per cent of the total anthropogenic greenhouse gas (GHG) emissions when the emissions associated with pre- and post-production activities are considered (Mbow and others, 2019).

"The transformational vision of the *2030 Agenda for Sustainable Development* calls on all countries and stakeholders to work together to end hunger and prevent all forms of malnutrition by 2030" (FAO and others, 2017). Additionally, Sustainable Development Goal (SDG) 12 has a target (12.3) that aims to halve per capita global food waste and reduce food losses by 2030 (UNGA, 2015). Moreover, all SDGs are directly or indirectly linked to food system and food security (FAO and others, 2017; Mbow and others, 2019). Considering these inter-linkages are important because the 2030 Agenda is a system of interacting components that is more than a collection of goals, targets and indicators (Pradhan, 2019).

The recent International Plant Protection Convention (IPPC) Special Report on Climate Change and Land (SRCCL) highlights that the food system and all the four pillars of food security is under pressure from non-climate stressors (e.g., population and income growth, demand for animal-sourced foods), and from climate change (Mbow and others, 2019). This brief note presents interactions between climate change, food system and sustainability, highlighting urban food system and regional specificities, by summarizing the recent literature including the SRCCL. The main purpose of this brief note is to inform the United Nations expert group meeting held by the United Nations Department of Economic and Social Affairs, Population Division on the special theme of "Population, food security, nutrition and sustainable development". After this background, section 2 describes drivers of food system. Interactions between climate change and food system are discussed in section 3. Response options to ensure food security in a sustainable manner are presented in section 4. Sections 5 and 6 present urban food system and regional specificities, respectively. Section 7 highlights the key conclusions of this brief note.

## *2. Drivers of food system*

According to the SRCCL, "the food system encompasses all the activities and actors in the production, transport, manufacturing, retailing, consumption and waste of food, and their impacts on nutrition, health and well-being, and the environment" (Mbow and others, 2019). Food security and environmental impacts (e.g., climate change due GHG emissions) are outcomes of food system. In return, complex interactions between food system and the environmental impacts can lead to food insecurity by affecting all the four pillars. The section highlights drivers of "food demand", an important component of the food system, because increasing demand of food is the main argument given for producing more food.

### 2.1 Population growth

The global population has grown from 3 to 7 billion people with an increased in the share of urban population from 34per cent to 51per cent between 1960 and 2010 (FAO, 2018a). This population growth and urbanization is one of the major drivers for increase in food demand and production in the last five decades. By 2050, the global population is projected to reach 8.5 to 10 billion people under scenarios ranging from a sustainable to fragmented world as depicted by storylines of the shared socioeconomic pathways (SSPs) (Kc and Lutz, 2014). Additionally, around two third of the global population (68 per cent) is projected to live in urban areas by 2050 (UN-DESA, 2019). For feeding this growing population, food demand has been projected to increase by 40-60per cent between 2010 and 2050 under different scenarios (FAO, 2018b; Bodirsky and others, forthcoming). However, the increased food demand is not only driven by growing population but also due to shifting lifestyles owing to increasing income, leading to changes in consumption patterns.

### 2.2 Changes in consumption patterns

Globally, consumption patterns have changed both in term of amount and compositions in the last decades (Pradhan and others, 2013b). Mainly, a higher amount of calories is available with increased shares of animal sourced foods, vegetable oils and sugar and sweeteners (FAO, 2018a). Additionally, an increased share of crops has been used to produce animal sourced foods. In 2010, around 40per cent of the global crop production is used as livestock feed (Pradhan and others, 2013a). Moreover, the increasing food availability across the world is not only due to changes in consumption patterns but also driven by growing food waste. During the last five decades, the global food waste has grown from 310 to 510 kcal/cap/day (Hiç and others, 2016).

These changes in consumption patterns towards energy dense diets have resulted in about 2 billion adults now facing overweight or obesity (Mbow and others, 2019). Current dietary patterns across the world deviate from recommended health diets (Willett and others, 2019; FAO/WHO/UNU, 2004) either with too much or too little food supply, resulting in malnourishment.

Many studies have shown that changes in consumption patterns are related to growing incomes and increasing development (Pradhan and others, 2013b; Bodirsky and others,; Popp and others, 2010). Therefore, we can expect further changes in consumption patterns toward energy dense diets once the current development trend continues. These changes in consumption patterns would demand more food, increasing environmental impacts associated with food system and put pressure on public health with an increase in the burden of non-communicable diseases (Willett and others, 2019; Bodirsky and others, forthcoming; Springmann and others, 2016). Additionally, Bodirsky and others (forthcoming) highlight that although population with overwieght and obesity will increase in the future, undernourishment would contibue to prevail in few countries by 2050 when current trends contiue.

## *3. Interactions between food system and climate*

Food system is a driver of climate change as it contributes to around one third of the global anthropogenic GHG emissions (IPCC, 2019). These emissions include emissions inside farm due to agriculture and land use change and outside farm gate emissions from energy, transport and industry sectors of food supply chain. Food system and climate change interact in a complex manner resulting in food system driving climate change and in turn climate change leading to food insecurity. This section briefly highlights these complex interactions.

### 3.1 Impacts of food system on climate change

Food system impacts climate via emissions of $CO_2$ and non-$CO_2$ GHGs, by its activities and actors. Specifically, these emissions are generated from: i) production of crop and livestock (within farm gate emissions, also known as emissions from "Agriculture"), ii) land use and land use change due to agriculture (also known as emissions from "Land Use"); and iii) energy use for food production, transport and processing, including both upstream and downstream processes (also known as emission "Beyond Farm Gate") (Mbow and others, 2019). The SRCCL has estimated emissions from "Agriculture" of 6.2±1.4 Gt $CO_{2\text{-eq}}$ $yr^{-1}$, from "Land Use" of 4.9±2.5 Gt $CO_{2\text{-eq}}$ $yr^{-1}$ and from "Beyond Farm Gate" of 2.4–4.8 Gt $CO_{2\text{-eq}}$ $yr^{-1}$, resulting in the total emissions from food system of 10.7–19.1 Gt $CO_{2\text{-eq}}$ $yr^{-1}$ (i.e., 21-37per cent of the total anthropogenic GHG emissions), during the period 2007-2016 (IPCC, 2019; Mbow and others, 2019).

In food system, animal source foods are the major contributor of the GHG emissions. Gerber and others (2013) has estimated the emission from livestock system of 7.1 Gt $CO_{2\text{-eq}}$ $yr^{-1}$. This makes the livestock emission share of 37–66per cent of the food system emissions. The SRCCL highlights that the main source of global livestock emissions is cattle production (Mbow and others, 2019) that is also a source of red meat. Recent studies report that red meat is carcinogenic to humans whether it is eaten in processed or unprocessed from (Bouvard and others, 2015).

### 3.2 Impacts of climate change on food system

Climate change has already been affecting food system leading to food insecurity through impacts on its four pillars (availability, accessibility, utilization and stability), which will be exacerbated under projected future climate change (Mbow and others, 2019). Food availability could be reduced by decrease in crop yields due to climate change in the future. The SRCCL highlights negative impact of increase in temperature on crop and livestock production at the global scale. Food accessibility for vulnerable people could be limited by raising food prices due to decrease in crop production as a result of climate change. In SSP2 scenarios (i.e., with medium challenges to mitigation and adaptation), a median increase of 7.6per cent (range of 1 to 23per cent) in cereal prices is projected by global crop and economic models in 2050 (IPCC, 2019). This increase in food prices leads to an increased risk of food insecurity and hunger. Additionally, growing $CO_2$ concentration in the atmosphere is projected to lead to lower nutritional quality of crops, affecting food utilization aspects. Moreover, climate change will also alter distribution of pests and diseases with negative effects on food quality (Mbow and others, 2019). Food stability will be impacted by growing magnitude and frequency of extreme events due to climate change via increasing disruption on food production and supply chains.

## *4. Response options and co-benefits*

For fixing the broken food system, Schmidt-Traub and others, (2019) proposed three steps consisting of i) agree a framework, ii) build national models and iii) build a global network. More specifically, the SRCCL provides a list of response options throughout the food system, from production to consumption, which can be applied for climate change mitigation and adaptation resulting in improvements in food security (IPCC, 2019; Mbow and others, 2019). Some of these response options also provide health co-benefits. Tools such as the global calculator[2] and the European calculator[3] are also available to understand climate change adaptation and mitigation benefits of some of the food system response options.

### 4.1 Improved crop and livestock management

Various response options are available to improve crop and livestock management so that food system can become climate adaptive while mitigating climate change. The response options for improve crop management includes: increased soil organic matter content, change in crop variety, improved water management, adjustment of planting dates, precision fertilizer management, integrated pest management, biochar application, agro-forestry, changing monoculture to crop diversification, residue management, etc. On livestock, the improved management options are: silvopastoral system, new livestock breed, livestock fattening, shifting to small ruminants or drought resistant livestock or fish farming, feed and fodder banks, methane inhibitors, thermal stress control, seasonal feed supplementation, improved animal health and parasites control, etc. (Mbow and others, 2019). A recent case study on silvopastoral system of Colombia shows that the implementation of silvopastoral system even with moderate tree planting can reduce GHG emissions by 2.6 Mg $CO_{2\text{-eq}}$ $ha^{-1}yr^{-1}$ in comparison to traditional livestock system with an increase in agriculture productivity and restoration of degraded land (Landholm and others, 2019). By 2050, the total

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[2] See http://tool.globalcalculator.org/

[3] See http://tool.european-calculator.eu/

technical mitigation potential from improved crop and livestock management activities, including agroforestry, is estimated as 2.3-9.6 Gt $CO_{2-eq}yr^{-1}$(IPCC 2019).

### 4.2 Improved supply chain

The response options to improve food supply chain includes: shortening supply chains, improved food transport and distribution, improved efficiency and sustainability of food processing, retail and agri-food industries, improved energy efficiencies of agriculture, reduce food loss, urban and per-urban agriculture, and bioeconomy (e.g., energy from waste). A recent study by Kriewald and others, (2019) shows that around 1 billion people living in urban areas can be nourished by utilizing the global peri-urban food production potential, which could also reduce carbon emissions related to food transport. For having these effects of emission reduction, urban and per-urban agriculture need to be accompanied with consumption of regional and seasonal food (Pradhan and others, forthcoming). Shortening supply chains and consuming local food can reduce GHG emissions when foods are grown efficiently. In some cases, local food may embody larger emissions than imported ones due to emission inefficient production systems (e.g., heated greenhouse system, low productive system, etc.) (Mbow and others, 2019).

### 4.3 Demand management

The response options on demand management consist of dietary changes and reduction of food waste. In contrast to the current trend of changing consumption patterns toward energy dense diets, dietary changes towards balance diets consisting plant-based foods, such as coarse grains, legumes, fruits and vegetables, nuts and seeds and limited animal-sourced food produced, can reduce GHG emission and improve public health (Willett and others, 2019; IPCC, 2019). By 2050, dietary changes toward balance diets would mitigate GHG emission of 0.7-8 Gt $CO_{2-eq}yr^{-1}$(IPCC 2019). Food waste reduction also contribute to lowering GHG emissions and climate change adaptation by decreasing the land area required for food production (IPCC, 2019). In 2010, around 20per cent of the available food is wasted by consumers (Hiç and others, 2016). Food lost and waste contributed around 10per cent of the total anthropogenic GHG emissions during 2010-2016 (IPCC, 2019).

## *5. Urban food systems*

Urban areas play an important role in food system both as consumers and producers of food. Currently, more than half of the world's population lives in urban areas and considered as a crucial driver of food system in regard to supply chains and dietary changes (Mbow and others, 2019). By 2050, two thirds of the global population will be living in urban areas, putting cities increasingly in focus for achieving food security for 10 billion people by 2050. Therefore, choices made on how to nourish growing urban population will have major consequences on global sustainability. This section mainly focuses on two aspects of urban food systems, i) urban and peri-urban agriculture, and ii) urban food transport, among various actors and activities of urban food systems. This is because urban and peri-urban agriculture will play very important roles in nourishing the growing population and considering urban food transport is crucial for the global sustainability in a broader context.

Urban and peri-urban agriculture has a great potential to nourish the global urban population, which will be reduced in the future under scenarios of climate change, consumption pattern changes and urban growth. In 2010, urban and peri-urban agriculture globally covered an area of 2.15 million $km^2$, i.e., 8.5per cent of the global arable land and provided food for 15.8per cent of the global population, i.e., 30.6per cent of the global urban population (Kriewald and others, 2019). By closing crop yield gaps in urban and peri-urban areas, 35.3per cent of the global urban population could be nourished. In future, this nourishment potential however, will be deceased in all the cities due to climate change, consumption pattern changes and urban growth. Looking at the world's regions, urban growth will have the largest impact on the future urban and peri-urban agriculture in 16 out of 19 regions (i.e., sub-continents). Changing consumption patterns toward energy dense diets will have the second largest impact for 9 regions (Kriewald and others, 2019).

For nourishing urban inhabitants, food needs to be transported over long distances (Weber and Matthews, 2008) beyond urban and peri-urban agriculture, resulting in GHG emissions. Under current business models, reducing the global transport emissions is a challenge because the demand to move people and goods around the world is growing. A comparison between *regionalized* food systems (where urban food and feed demands are fulfilled by the nearest possible surroundings) and *globalized* food systems (where the demands are randomly met form the global pool of producer areas) shows that *regionalized* food systems would halve the current emissions from food transport (Pradhan and others, forthcoming). Conversely, the emissions are four times higher (1.87 Gt $CO_2$ $yr^{-1}$) under *globalized* systems. By 2050, the food transport emission may increase to 0.25--0.92 Gt $CO_2$ $yr^{-1}$ and 2.20--3.00 Gt $CO_2$ $yr^{-1}$ under *regionalized* and *globalized* food systems, respectively (Pradhan and others, forthcoming). Thus, regionalization of urban food systems based on urban and peri-urban agriculture will contribute to climate change mitigation. Additionally, *regionalized* food systems also help to reconnect consumers and producers to fix the broken food system.

*6. Regional specificities*

This section briefly provides regional specificities for food systems in South Asia, considering the four pillars of food security. During the last decades, situation of food security has been improved in South Asia. However, there are also early signals of nutritional transitions from food deficit to over consumption in the region. Therefore, the region needs to tackle both problem of prevalence of undernourishment and overweight/obesity to end all forms of malnourishment as envisioned by SDG2. Additionally, greenhouse gas emissions from the agricultural sector are increasing in South Asian countries.

Looking at the four pillars, food availability has been improved in South Asia, mainly by increase in crop production and growing trade (FAO, 2018a). For nourishing the growing population with changing dietary habits, the region could produce more food by closing crop yield gaps (Pradhan and others, 2015).

Food accessibility has been improved in the region due to growing per capita income and availability of enough and diverse types of food. However, food prices have also been increased in these countries during the last decades, creating a barrier to food accessibility (FAO, 2018a). A large share (more than 45per cent) of expenditure for household consumption in these countries is used for purchasing food in the region (World Bank, 2018).

On the food utilization aspect, the food supply in South Asia deviates from the recommended diets, mainly with a lower amount of fruits and vegetables. A decreasing trend in prevalence of undernourishment and underweight in the region was also observed. However, prevalence of overweight and obesity have been increasing (Abarca-Gomez and others, 2017). Still, undernourishment prevails in South Asian countries (FAO and others, 2018).

On a broader sense, annual food stability in the region has been maintained by increasing crop yields (FAO, 2018a). However, the current crop yield growth rate would not be enough to double food production by 2050 in the region. Impacts of climate change and extreme events should also be considered while assessing the future food stability in the region.

*7. Conclusions*

In conclusion, food system is currently broken as it is unable to provide nutritious food for all the population and is also contributing to climate change and other environmental problems. However, response options are available throughout the food system, from production to consumption, which can be applied for climate change mitigation and adaptation resulting in improvements on food security. In other words, the implementation improved crop and livestock management practices together with approaches to improve supply chain and strategies to limit overall food demand, such as dietary changes and food waste reduction, are needed to fix the broken food system. Some of these response options also provide health co-benefits. Therefore, considering food system approach from plant to plate and all the four pillar of food security would be a way forward to achieve food security in a sustainable manner for the growing population.

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