Middle East Journal of Agriculture Research Volume : 09 | Issue : 02| April-June | 2020
EISSN: 2706-7955 ISSN: 2077-4605 Pages: 349-376
DOI: 10.36632/mejar/2020.9.2.28

Climate Smarting Local Rural to Urban Food Systems with the Green Food Value Chain Development approach: What lessons can be learnt?

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Received: 21 March 2020 / Accepted 10 May 2020 / Publication date: 20 May 2020

ABSTRACT

The main objective of the research was to investigate further, via literature, secondary sources of data and information and field work conducted in one city, Erbil, Iraq, the climate smarting of local food systems considering the rural, peri-urban and urban context. The research in particular focused on looking at climate smarting local food value chains, via the green food value chain development approach, and attempting to verify what lessons may be learnt. A local-based perspective, green food value chain development, enables concrete actions to be taken where, in fact, the majority of activities in food systems take place. The approach, takes a holistic and systemic focus on developing food value chains with an overall environmental perspective and priority, in other words greening and climate smarting. The article provides for an initial context in terms of increasing climate change, natural environment degradation, and the incremental rise of population concentrations in peri-urban and urban areas and how such challenges have and are fundamentally altering food system operations for providing food security. It characterises food systems and food value chains within this context, considers how food systems affect climate change, describes the green food value chain development approach and provides for research findings derived from literature, secondary sources of data and information, and from filed work conducted in one city, Erbil, Iraq. The findings provided that, for example, strengthening rural to urban linkages and improving governance and implementing regulations, foster and enhance a low-carbon development pathway. From the findings a number of lessons were learnt, for example, the need for a systemic and holistic process that enables synergy among the various factors that contribute and enhance climate smarting and greening, to the centrality of multi-stakeholder partnerships and platforms, to awareness creation for climate smarting and greening targeted at policy-makers, provided by an effective communication strategy. Such lessons learnt also contributed to further enhancing knowledge and know-how of the green food value chain development approach, and at the same time, identified further areas for research.

Keywords: climate smarting, local food systems, rural-urban linkages, green food value chain development

Introduction

The context

There is now a growing recognition that tendering to environmental problems, and in particular here on climate smart-low-carbon development[1], rests almost entirely on getting the economy right and this means fostering green growth: this is defined as economic growth and development that ensures that natural assets continue to provide the resources and environmental services on which society's well-being relies (OECD, 2011). At the basis of green growth is the green economy which fosters improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (UNEP, 2011a) considering, importantly, the economic efficiency of such processes. In a green economy, growth in income and employment is driven by public and

[1] This is better known as low emission development strategies (LEDs) (OECD & IEA, 2011). Low emission development strategies (LEDs) are forward-looking national development plans or strategies that encompass low-emission and/or climate-resilient economic growth (OECD & IEA, 2011).

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private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services (UNEP, 2011a). These investments need to be catalysed and supported by targeted public expenditure, policy reforms and regulation changes (UNEP, 2011a). This development path should maintain, enhance and, where necessary, rebuild natural capital as a critical economic asset and source of public goods, especially for poor people whose livelihoods and security are vulnerable (UNEP, 2011a). Green growth policies must be carefully designed to maximize benefits for, and minimize costs to, the poor and most vulnerable, and policies and actions with irreversible negative impacts must be avoided (World Bank, 2012a).

As countries develop and progress economically, urban centres tend to play a more dominant role in consumption, production and pollution, and are associated with serval environmental issues, including air pollution, greenhouse gas emissions (GHGEs), waste and poverty, but at the same time such concentrations of people, activities and resources provide for increases in efficiencies and multi-purpose solutions (McCormick, 2015). The growth in cities results less from a shift in population from rural to urban areas than from a rapid population growth within cities themselves: on average, with a few exceptions such as China, 75 percent of urban growth is a result of net urban births (Reardon, 2016).

There is a close association between urbanization, economic growth and development, this being based on population size, economic density[2] and territorial specialization (World Bank, 2012b). As urbanization increases and expands the concentration of economic activity suggests that the richer the area, the more economically dense it is. However even though urbanization is strongly correlated with economic growth, it does not cause growth, but does provide growth enhancing benefits (Khan *et al.,* 2016).

The so called ‘second wave’ of urbanization, which sees more than half of the world population residing in urban areas, comes at a time of resource scarcity and constraint and increased uncertainty, especially in terms of climate change effects that exacerbate resource scarcity and increased unpredictability of resource availability (UNEP, 2012). Within this territorial context, cities represent a challenge and an opportunity for climate change: responsible for most of the world’s economic activity, population, innovation, output and employment, cities arguably produce most of the global GHGEs, but at the same time and especially for cities located along coastal regions, are vulnerable to the effect of climate change, such as urban heat island effects (World Bank, 2012b).

There are about four billion people who live at the bottom of the economic pyramid, termed bottom of the pyramid (BOP). Currently, 736 million people, or 10.9 percent of the world population, live in extreme poverty, with an income of less than US$1.9 per day, while 3 billion live on US$2.5 per day and represent about 40 percent of the world population (World Bank, 2018, World Bank 2016a). Within this context of poverty, the forecast surge in world population and its related concertation in peri-urban and urban areas, comes the related quest for increased food production and more improved, far reaching and intensified food distribution. Increased food production and distribution though, have to tender to some daunting challenges, of which, the main ones being, poverty, climate change[3], the depletion of natural resources and the degradation of the natural environment. Consequently, moving away from food production and distribution models that are based on unsustainable extraction and consumption alone is a priority objective for increasing food security, improved nutrition and overall social welfare. In fact, with an appropriately used, and consequently, well-functioning natural environment, the required increases in food production and

[2] This refers to the economic mass or output generated per a unit of land, is measured by the value added or GDP generated per square kilometre of land and is higher the more concentrated such factors as capital and labour are. Thus economic density is highly correlated with employment and population density (Word Bank, 2012b)

[3] Over the last four decades, climate change has significantly affected biodiversity, food systems and human health across the globe (Tumwesigye *et al.,* 2019).

food distribution can be provided for. A functioning natural environment can cater for food availability, accessibility, affordability and adequacy (food security) in the ever growing landscape of food production and distribution and moreover a well-functioning natural environment tends to have social mitigation effects as conflicts over basic access to such a resource, food, are prevented. Thus and overall food systems have an important positive contribution to make in building a sustainable environment and combating climate change (Bricas, 2019).

Scope and objective of the research

The scope of the research was to look at climate change mitigation and adaptation measures in climate smarting local food systems. The main objective of the research was to investigate further, via literature, secondary sources of data and information and field work conducted in one city, Erbil, Iraq, the climate smarting of local food systems considering the rural, peri-urban and urban context. The research in particular focused on looking at climate smarting local food systems, considering the green food value chain development approach, and attempting to verify what lessons may be learnt.

Methodology

An initial in-depth historical, exploratory and descriptive literature research and review[4] was conducted between March and May 2018. This was followed by semi-structured telephone interviews conducted with key informants, identified in rural, peri-urban and urban areas of Erbil, Iraq. A total of 23 key informants had been initially identified and 16 interviews were implemented in the period September to November, 2018. The results of this first research provided for ‘guidelines’ to conduct a second in-depth literature research and review[5] that was conducted between January and February 2019 and conducted in parallel with a research for secondary sources of data and information. Semi-structured telephone interviews were conducted with 37 key informants, in rural, peri-urban and urban areas of Erbil, Iraq, from an initial identified sample of 53 key informants, between March and May, 2019. A final in-depth literature research and review[6] was conducted between December 2019 to February 2020.

The food system and the food value chain

A food system can be defined as an interconnected web of activities, resources and people that extends across all domains involved in providing human nourishment and sustaining health, including production, processing, packaging, distribution, marketing, consumption and disposal of food (Chase & Grubinger, 2014). Within an overall food system, smaller systems exist, such as farming systems, ecosystems, social systems, energy systems, policy systems and culinary systems, etc. Environmental systems, overlap with the food system, and they can be explored at different levels, from a single field, to a whole farm, to the local, region or global food system and the flows and cycles, which occur inside and outside of the system of carbon, energy, nutrients, pollutants, waste and a host of other features can be described as individual systems (Chase & Grubinger, 2014). Moreover, economic systems are powerful drivers of decisions and can provide ‘tools’ for valuing externalities both positive and negative, for example, prizing carbon reducing efforts by food system actors and sanctioning (taxing) those that have high carbon emissions. Such market mechanisms for externalities, for example, help society capture ‘true’ values of differing practices of a food system (Chase & Grubinger, 2014).

The organization of food systems reflects and responds to social, cultural, political, economic, health and environmental conditions and can be identified at multiple scales, from a household kitchen to a city, country, state or nation (Chase & Grubinger, 2014). Importantly, these factors, along with individual perspectives, will determine how a food system will be envisioned and described

[4] The literature research was conducted using the on-line data bases of Research Gate, World Bank e-library, Google Scholar, JSTOR and FAO document repository

[5] The second literature review was conducted using the on-line data bases of Research Gate, World Bank e-library, Google Scholar, JSTOR, Wiley online library and Youtube

[6] The third and final literature review was conducted using the on-line data bases of Research Gate, World Bank e-library, Google Scholar, JSTOR, Wiley online library and FAO document repository

Middle East J. Agric. Res., 9(2): 349-376, 2020
EISSN: 2706-7955 ISSN: 2077-4605 *DOI: 10.36632/mejar/2020.9.2.28*

ranging from a simple direct farm to market system to a more complex and broad-reaching set of interactions, which go far beyond the production, processing and distribution of food to include the connection of food to the health of people and the environment (Chase & Grubinger, 2014). Food systems can be of various types, such as traditional, intermediate and modern: traditional food systems are usually, but not always less resource intensive, while modern food systems are commonly the contrary and intermediate food systems are some where in-between in terms of resource intensity[7] . Brown and Mata (2016) refer to mechanized and non-mechanized food systems. Table 1 shows and compares some of the features of such food systems.

Table 1: Food system typology comparison

Food system feature	Traditional food systems	Intermediate food systems	Modern food systems
Estimated number of people in system	1- Billion	4- Billion	2- Billion
Principal employment in food sector	In food production	In food production	In food processing, Packaging and retail.
Supply chain	Short, local; small-scale Structures	Short to longer, supply chain has typically more actors than in 'modern' food systems	long with many food miles and nodes; consolidation in Input, processing and food retail segment; transnational companies and chains
Supply chain coordination system	Ad-hoc, spot exchange	Mainly ad-hoc, spot exchange	Contracts, standards. vertical integration
Food production system	Diverse, mixed production system (crops and animal production), varied productivity; low- Input farming system Food system are the main source of energy	Combination of diverse, mixed production system and specialised operations with a certain degree of inputs, including fossil fuels	Few crops dominate (e.g. monoculture); specialism and high productivity; high external input intensity, including fossi1 fuels., Food production consumes more energy than it delivers.
Typical farm	Family-based, small to moderate	Combination of small holder farms and larger farms/fishery operations	Industrial, larger than In a traditional setting
Typical food consumed	Basic locally. produced staples	Combination of basic products and processed food	Larger share of processed food with a brand name, more animal products
Food bought from	Small. local shop or market	Small. Local shop or market. share of supermarkets small but rapidly growing	Predominantly large supermarket chain, food Service and catering (out of home)
Nutritional concern	Under nutrition	Both under nutrition and diet-related diseases	Diet-related diseases
Main source of national food shocks	Production shocks	International price and trade problems	International price and trade problems
Main source of household food shocks	Production on shocks	International shocks leading to food poverty_	International shocks leading to food poverty
Major environmental concerns	Solid degradation, land clearing, water shortage	Combination of concerns in traditional and modern systems	Emissions of nutrients and pesticides, water demand, greenhouse gas emission., and others due to fossil fuel use
influential scale	Local to national	Local to global	National to global

(Source: UNEP, 2016)

[7] Resource intensity depicts the amount of natural resources used to produce a certain amount of value or physical output. It is calculated as resource costs per value added or resource use (in quantity) per physical output (UNEP, 2016)

Each typology of food system has an embedded food value chain. A food value chain can be defined as a system composed of different actors, activities and institutions, that are interconnected, so as to enable the accomplishment of a common goal (FAO, 2007): it takes food from farm to fork. The stages commonly include: preproduction (inputs), production (farm), transformation (processing), distribution (transport/retailing), consumption (diets) and post consumption (waste, etc,).

A value chain can be national if all stages occur within a country or global if different stages take place in different countries (ADB, 2016). Local value chains, more often than not provide for the different stages within a defined local area, and may be also related to an enterprise's value chain, while regional value chains operate within a defined region of a nation. Like the differing types of food systems, such food value chains all have geographical boundaries.

Seeing the mandated necessities to counter act climate change and develop food systems, and the embedded food value chains, in a low-carbon manner, that are also pro-poor and inclusive, a bottom-up perspective, a green food value chain approach is considered (see Hilmi, 2018). In particular, the focus is on a locally-based perspective, rural and urban, that enables concrete actions to be taken where, in fact, the majority of activities in food systems take place.

Food systems and climate change

There is considerable evidence to suggest that increased rainfall and temperature affect food availability, utilization, crop yields, food markets, food prices, consumption patterns and food insurance (Tumwesigye *et al*., 2019). In fact, under such climate change conditions, the stability of food systems and inherent food value chains may be at risk, largely due to short-term variability and extreme events in agricultural markets (FAO, 2015a). Vulnerability of food systems is widespread and human and non-human -caused climate change will influence the quality and quantity of food produced and the ability to distribute it equitably, but the adaptive capacity to climate impacts varies by income and sub-sector (Myers *et al*., 2017; Brown & Mata, 2016). Thus the agri-food sector, and its inherent food systems and food value chains, needs to find ways of reducing its environmental impact, which includes GHGEs[8] , natural resource depletion and biodiversity and ecosystem services usage.

Over the past 50 years GHGEs have nearly doubled as a result of agri-food sector activities (FAO, 2016b). Agricultural production is a major source of such emissions and if considering also processing, trade and consumption of food, the total amount of GHGEs from the sector contributes around 26 percent of total GHGEs (FAO, 2016b). In specific, food systems are currently responsible for up to one-third of anthropogenic GHGEs and such emissions include carbon dioxide, methane and nitrous oxide and are a major driver of climate change (Demenois *et al*., 2019). It is estimated that by 2050 GHGEs will increase between 80 and 92 percent in the absence of technological change and other mitigation measures (Demenois *et al*., 2019). Consequently, for food systems to become more carbon-sensitive will require less GHGEs per unit of food produced and distributed. Greenhouse gas emissions (GHGEs), however, are only one part of a much wider picture of the environmental impacts of food systems and thus requires more holistic approaches to address the multitude of issues that provide for GHGEs[9]. A food systems approach breaks down entrenched sectoral categories and existing adaptation and mitigation silos, presenting novel ways of assessing and enabling integrated climate change solutions from production to consumption (Rosenzweig *et al*., 2020).

There is mixed evidence to whether long-distance food systems, such as global food systems have higher emissions than local food systems. The level of overall GHGEs from a food system is not only determined by the level of the food system, for example local and global food system, but also

[8] This intended in both direct and indirect GHGEs. Direct GHGEs derive directly from the activities and operations being conducted in the food system, for example, while indirect GHGEs derive, for example, from packaging material production that results in packaging being used for a food product.

[9] One methodology for climate smarting food systems at the local-field level, in a more holistic way, is green food value chain development (Hilmi, 2014; FAO & CIHEAM, 2016; Hilmi, 2016a; Hilmi, 2016b;Hilmi, 2016c; Hilmi, 2018; Hilmi 2019a; Hilmi, 2019b).

by the stages of the food value chain (pre-production, production, processing, storage and distribution), the food product, the type of farm operation, transport, season and the scale of production. Greenhouse gas emissions (GHGEs) vary markedly across the different activities (stages) of a food value chain as shown in Table 2. They also vary by country, for example, in high income countries, post production stages tend to have a greater role in GHGEs, and also vary per economic subsectors, for example fertilizer manufacturing (Vermeulen, *et al*., 2012). The apparent trend though, is that overall in the future, GHGEs from food systems will be associated with the post-production stags of the system (Vermeulen, *et al*., 2012).

Table 2: Estimates of GHGEs per stage in a food value chain

Stage of food chain		Emissions (M_tC0_{2e})[b]	Year of estimate
Preproduction	Fertilizer manufacture	282-575	2007
	Energy use in animal feed production	60	2005
	Pesticide production	3-140	2007
Production	Direct emissions from agriculture	5,120-6,116	2005
	Indirect emissions from agriculture	2,198-6,567	2008
Postproduction[c]	Primary and secondary processing	192	2007
	Storage, packaging, and transport	396	2007
	Refrigeration	490	2004
	Retail activities	224	2007
	Catering and domestic food management	160	2007
	Waste disposal	72	2007

(Source: Vermeulen, *et al*., 2012)

There are significant opportunities to decouple food system activities from environmental degradation in terms of sustainable resource management and increasing the efficiency of such resource usage (UNEP, 2016). Sustainable resource management is about mitigating (preventing) the over-exploitation and degradation of natural resources, while increasing the efficient use of all resources in all food system activities, which will help move towards a more environmentally-friendly use of renewable resources, lower environmental impacts and lower depletion rates (UNEP, 2016). However, options for greener and lower-carbon food value chains are context specific and location dependent, but could include: more effective use of ecosystem services, better feed conversion, better recycling and use of by-product and food waste, more energy and water efficient food processing, reduction of losses in the food system and reduction of over-consumption and change of unhealthy dietary patterns (UNEP, 2016). A food system is considered more resource efficient when more food is produced and finally consumed with the same amount of resources, or when the same amount of food is produced with fewer resources (UNEP, 2016). The relationship of food system activities, resource use and environmental impacts can be seen in Figure 1.

The impacts of food system activities on the natural environment are leading to numerous and unintended impacts. Some examples of these can be seen in Table 3.

Currently, food system estimated total anthropogenic emissions are between 21–37 percent (Rosenzweig *et al*., 2020), thus a thorough analysis of existing food systems can assist in identifying the most important matters regarding natural resources and climate change as well as the opportunities for effective policy, fiscal, social and/or technical interventions (UNEP, 2016). In this context and to identify such opportunities, national or better still local food systems need to be properly analysed (UNEP, 2016).

Mitigation refers to actions that are taken to prevent and reduce GHGEs, for example using solar energy in food processing or reducing the use of fossil fuel in more efficient food transportation vehicles. Adaptation refers to actions that are taken to adjust to the effects of climate change, for example, modifying storage structures that can withstand better weather and temperature extremes. Mitigation and adaptation are more than a set of technological and institutional innovations: they constitute social learning processes that must address differences among people's values, capacities and vulnerabilities. Coordinated actions are required for climate change adaptation and mitigation and require policies and actions both to make food systems more resilient to climate variability and change and to mitigate GHGEs (Vermeulen *et al*., 2012).

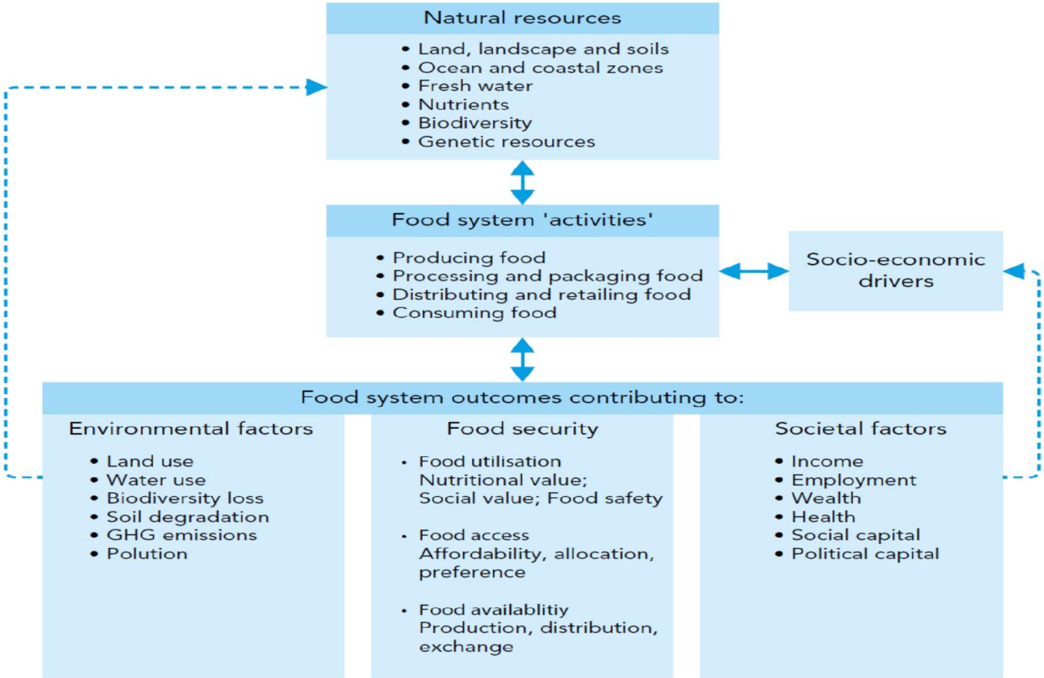

Fig.1: The relation between resource use, environmental impacts and food system activities. (Source: UNEP, 2016)

Table 3: Food system activities and its impacts on the natural environment

Environmental impact	**Food system activity**				
	Producing food	Processing & packaging food	Distributing & retailing food	Consuming food	Managing waste
GHG Emissions	fertilizer production and use; irrigation; tillage; machinery; livestock; rice, land conversion	cooking; cleaning; machinery	trucks; cold chain leakages; outlet heating & lighting	cooking; catering; restaurants	burning residues; landfill
Air quality	forest burning and pastures; dust; ammonia emissions (mainly from livestock)	factory exhausts	truck exhausts	cooking smoke	Burning esidues and waste
Biodiversity loss	land conversion; intensification; hunting & fishing; habitat fragmentation	biomass for paper and card		charcoal; fuel wood	pollution
Soil quality	erosion; nutrients; salinization; compaction; soil organic matter decline; biotic decline	pollution	pollution		pollution
Water quality	eutrophication; pesticide pollution; sediment load	pollution; litter	emissions from shipping, coastal degradation	detergents;	pollution,litter, esp. plastics

(Source: UNEP, 2016)

But major trade-offs will also have to be taken into consideration in terms of the capacity of agriculture to mitigate its substantial contribution to GHGEs versus its capacity to supply a growing demand for food (Vermeulen *et al*., 2012). Specific technical and policy interventions must be situated within a broader holistic approach to agricultural and food systems management: for example net mitigation effects only occur if greater on farm efficiency does not displace emissions to other parts of the food system and further mitigation and adaptation actions need to be balanced against other environmental and social services, such as water use efficiency or equitable access to wild resources held in common property (Vermeulen *et al*., 2012). Sustained investments in institutions need to underpin any technical intervention to manage interactions between food systems and climate change and key investments include management and extension of knowledge and information at all levels, financial services, input and output markets, including markets for carbon and other environmental services (Vermeulen *et al*., 2012).

Trade within food systems and between food systems can cushion against large production shocks resulting from climate change and can compensate for production shortages or shifts in production patterns across regions (FAO, 2015a). Markets can play a stabilizing role for prices and supplies and provide alternative food options for negatively affected regions or by finding regions where food can be produced more efficiently, both in terms of environmental and economic costs. However, trade alone is not a sufficient adaptation strategy (FAO, 2015a).

In terms of food products and GHGEs rearing animals, eggs and milks generates some 14.5 percent of total global GHGEs, occupies 70 percent of agricultural land and is the main cause of environmental problems, such as biodiversity loss and water pollution (Garnett *et al*., 2015). Thus the activities to improve environmental efficiency are geared to producing more output and less negative impact per unit of input. In other words, environmental efficiency is not just a measure of the desired outputs relative to inputs, but also the desired outputs relative to undesired outputs or impacts (Garnett *et al*., 2015). Importantly a food system can be relatively environmentally efficient, but still have an impact on the environment, if consumption of the output increases faster than the efficiency gains (Garnett *et al*., 2015).

The principles of resilience, which focus on reducing risk and vulnerability, call for attention and support to multiple food sourcing strategies, a valuing of redundancy in the system, and wide access to information about sources of food. Such characteristics tend to go against the conventional norms of efficiency and centralization and instead favour food systems that are able to respond to food needs with agility. Environmental as well as economic uncertainties require food systems that are flexible, rely on good and easily accessible information to enable such systems to respond to changing and unpredictable circumstances (White & Hamm, 2014). Building local food resilience through boosted local food production and consumption, by incentivising agro-production around cities, provides for an 'insurance' against global price changes and climate change in particular that affects global food supply systems. Encouraging local food markets and agro-ecological produce are significant green measures for cities to take as they reduce their carbon footprint significantly by buying local, seasonal food and building local resilience towards global food supply system uncertainties (UNEP, 2012).

Climate smarting food systems: The green food value chain development approach

One approach to climate smarting food systems at the local level is the green food value chain development approach. It considers not only mitigation and adaptation, but also enabling and facilitating resilience. A green food value chain can be defined as one that needs to provide value at each stage by proactively reducing the usage of the natural environment (natural resources, ecosystem services, and biodiversity), to diminish or mitigate adverse impacts, or even have positive impacts, while at the same time considering disposal and recycling patterns of generated waste, to recapture value at every stage of the food value chain and thus further reduce environmental impact (Hilmi, 2018). This definition provides a basis on which to define a conceptual framework for developing green food value chains. The framework, shown in Figure 2, provides for a circular (and open-ended) nonlinear flow of forward and reverse food values that progress from the natural environment to final markets. The forward flows increase not only food economic value, but importantly food environmental, social, and cultural values; the food value that is wasted is recaptured with reverse flows that reset such food value from an economic, environmental, social, and cultural point of view. The intent is to provide for a holistic, circular, systemic and open-ended framework that inherently mitigates effects on the natural environment, attempts to adapt to changes, and at the same time attempts to replenish what has been used/consumed from the natural environment (Hilmi, 2018).

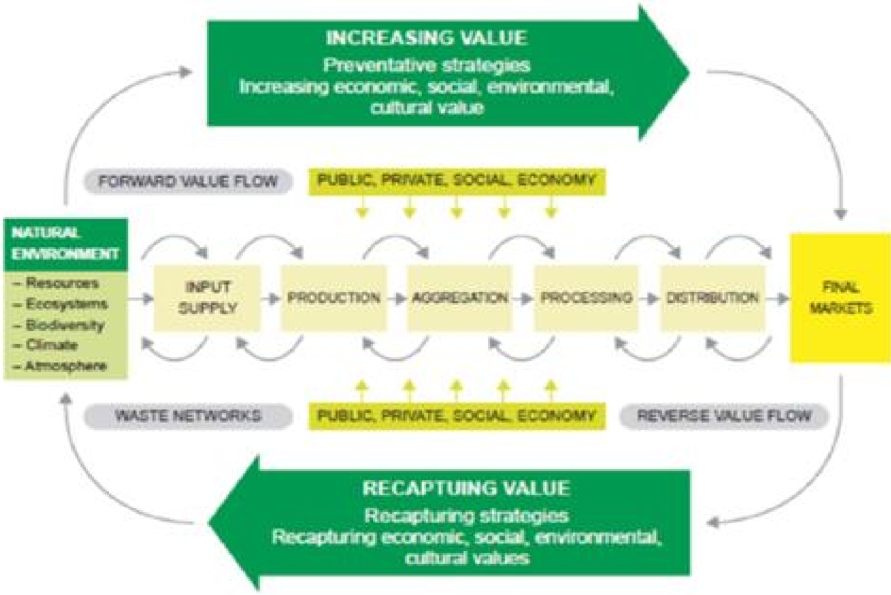

Fig. 2: The green food value chain development framework
(Source: Hilmi, 2014)

The process for developing green food value chains is one that is intended to suit the necessities, time lines, and especially budgets of those working at field level. The approach can have considerable impact on the appropriate use of the natural environment, for example reducing emissions and consequently contributing to low carbon development. Moving towards greener food value chains will require re-thinking of how organizations and individuals act, behave and operate in terms of greening, while at the same time providing for the same return on capital investments. This implies that every part of a food value chain must become more efficient by using less land, water, energy and other inputs, while still producing and delivering food sustainably and to become more resilient to changes and shocks (UNESCWA, 2014). Greening food value chains is composed basically of three main strategies: prevent, reduce and recapture that can be applied to all stages of the food value chain in terms of the stage's functions and activities, consequently fostering low-carbon development (see Box 1).

Box 1: The main strategies for green food value chain development

Preventive strategies

This considers understanding how preventive strategies for averting inappropriate use of the natural environment can be defined and importantly implemented all along the food value chain or in defined sections (stages) of it. This will not only pertain to purely functional aspects, but also look at how institutional and behavioral aspects can be geared to the prevention of the inappropriate use of the natural environment. Importantly, such strategies will need to build on and learn from existing greening competencies found within such food value chains and not introduce practices that are not part of the cultural context, are not economically and socially viable, and are convenient to implement.

Reduction strategies

Such strategies seek to reduce the inappropriate use of the natural environment where preventive measures are not feasible and/or applicable. In very much the same way as preventive strategies, reduction strategies require local adaptation and acceptance by food network stakeholders and blend in well with cultural, social, and economic contexts, and importantly need to be convenient to implement.

Recapturing strategies
This looks at strategies that can recapture any value to be found in waste derived from food value chain operations. In food value chains, more often than not food losses and waste may be inevitable because of the biological nature of food, for example, and thus such strategies for recapturing value from losses and waste need to be in tune not only with environmental priorities, but also and importantly social and economic priorities of stakeholders.
(Source: Hilmi, 2018)

The approach is a step-by-step process that attempts to learn from the field and from frugal innovations, and adapts this learning to the process. The step by step process can be seen in Box 2 in summary form. For the detail of the process see Hilmi (2018).

Box 2: The steps in the green food value chain development approach
Step 1: Form a multi-stakeholder working group
Step 2: Identify one or more food value chains that need green upgrading
Step 3: Select one or more specific food value chains for green upgrading
Step 4: Map one or more food value chains, provide for an environmental hotspot analysis and a Stakeholder analysis
Step 5: Set specific objectives and strategies
Step 6: Plan and action plan
Step 7: Set up a monitoring and evaluation system
Step 8: Hold regular multi-stakeholder working group meetings
Step 9: Attempt to contribute to and foster the development of a policy action plan
Source: (Hilmi, 2018)

The guideline was purposely designed in this manner so as to allow for adaptability, flexibility and morphing in the most diverse of local circumstances and contexts that can be found in local BOPs contexts. Some Steps are provided with 'tools' that have been field tested time and time again, for example in Step 2 *Identify one or more food value chains that need green upgrading*, suggested tools to be used are rapid market appraisal (see CRS, 2009), market research, (see Miehlbradt & Jones, 2007), and end-market analysis (see USAID, 2008). In Step 4: *Map one or more food value chains, provide for an environmental hotspot analysis and a stakeholder analysis*, one of the tools provided is hotspot analysis (see GIZ, 2015). Step 5 of the green food value chain development approach provides for three generic strategies that are adaptable to the most diverse circumstances (see Box 1). In other Steps, for example, suggestions are provided in text boxes on how to go about managing and importantly implementing such Steps.

In the step by step process, a large emphasis in the green food value chain development approach is based on learning from the BOP in terms of grass root (green/frugal) innovation technologies, activities, processes, systems, knowledge, know-how and behaviors in bout rural and urban contexts. Every community has an innovative capacity to come up with effective solutions to attempt to solve the problems they face on a daily basis and seek processes that are socially inclusive towards local communities and many communities have proven track records of being resilient to environmental challenges, as local knowledge has been co-evolving with nature for centuries, that rely on local raw materials and capabilities, are affordable and socially acceptable, such as organic farming and related sustainable land and water management practices (Pansera & Own, 2014). In fact, those who work in the informal food sector (and not only), be they grass root innovators, menial workers, etc., attempt to provide for solutions, frugal innovations, that take advantage of the many challenges they face daily and transform them into opportunities.

Innovations in such contexts, are commonly referred to as grassroot frugal and /or green innovations, where such innovations, based on local available raw materials and capabilities, contributes to the development and wellbeing of human needs with affordable, socially acceptable and culturally adaptable, accessible products, services, processes and technologies, while (attempting) to respect the worlds natural resources and regenerative capacity (Le Bas, 2016; Pansera & Own, 2016; Hilmi 2016a, 2016b). Such innovations, find opportunities in a context of adversity, do more with less, think and act with agility and aim for simplicity (Le Bas, 2016). Frugal innovation is a first step towards a greener economy and greener growth, with sensible connotations towards a more low-carbon economy and provides for a valuable and costless mechanism of adaptation and mitigation to climate change (Pansera & Sarkar, 2016, Hilmi, 2016b).

The green food value chain development approach, attempts to implement, the three strategies of prevent, reduce and recapture at every stage of the food value chain:

Pre-production

At the input stage of the food value chain, for example, manufacturing of fertilizer is a main source of GHGEs owing to its energy intensity, while the impact of GHGEs for manufacturing pesticides is not well known as per lack of information (Vermeulen, *et al*., 2012). In terms of feed for aquaculture and animals direct GHGEs derive from fossil fuel inputs in terms of cultivation, processing and transport of feed and indirectly through land-cover change both for grazing and for feed cultivation (Vermeulen, *et al*., 2012). In terms of making the food value chain greener and less carbon intensive, the input stage requires actions to be taken that prevent, reduce and recapture. In terms of prevention actions, for example solar driven manufacturing machinery can be used, which zeros any type of emissions from such machinery. In terms of reduction actions, feed production can apply a Save and Grow approach (FAO, 2011a) and thus considerably reduce emissions. In terms of recapturing actions, waste generated in the transport of feed can be recycled and reused for other purposes, such as composting. Such actions will all contribute to adaptation and mitigation making the food value chain more resilient.

Production

At the farming stage, for example, GHGEs are provided directly via agricultural practices and indirectly via land-cover change as a result of opening new agricultural lands (Vermeulen, *et al*., 2012). Here for example such preventive, reduction and recapturing strategies to the greening of the food value chain can be the application of the Save & Grow approach that is based on sustainable crop production intensification (SCPI). The basic premise of Save and Grow is to *produce more with the same*, it is a win-win model that enables higher yields by conserving resources. The approach uses resources efficiently, reducing negative impacts on the environment, while at the same time enhancing natural capital and the flow of ecosystem services (FAO, 2011a). Its focus is on nature's contribution to crop growth, such as soil organic matter, water flow regulation, pollination and bio-control of insect pests and diseases. It considers farming systems that incorporate conservation agriculture, soil health, improved crops and varieties, efficient water management and plant protection via integrated pest management (FAO, 2016b).

However, and clearly, such an approach needs to consider livelihoods and provide tangible advantages to small-scale farmers in terms of higher incomes, reduced costs as well as compensation for the environmental benefits generated. Studies conducted in 57 low-income countries found that more efficient use of water, reduced use of pesticides and improvements in soil health had led to average crop yield increases of 79 percent. A further study provided results that agricultural systems that conserve ecosystem services by using practices such as conservation tillage, crop diversification, legume intensification, and biological pest control, perform as well as intensive, high inputs systems (FAO, 2011a). In 2016 FAO provided a publication which reviewed the progress of the Save & Grow approach in terms of maize, rice and wheat and the review confirmed recent findings that over the past two decades, some of the most significant transitions to SCPI have been taken by smallholders in developing countries: growers worldwide have increased their productivity through the application of one or more of the Save and Grow farming system components (FAO, 2016b). Thus Save & Grow is a field-based bottom-up approach which interlinks very well in greening the production stage of food value chains and provides for the three main strategies of such an approach, based around: prevention of environmental impacts, reduction of environmental impacts and where waste occurs the recapture of value from waste. This all in the light of providing increased benefits to food value chain actors in terms of increased yields, incomes and improved local community habitats.

Commercialization

At the processing stage, GHGEs tend to be less in primary processing, commonly value addition at farm level and in micro-processing enterprises, and more in secondary processing activities, for example, medium-sized automated food processing enterprises, which tend to be more energy-intensive. At the retail stage modern retail outlets such as supermarkets, for example, are far more energy intensive than many traditional retail outlets found in many parts of the world. Information on packaging for GHGEs is scarce and difficult to interpret, as it may include manufacturing of such materials, the process of packaging, and a portion of refrigeration costs associated with the cold chain (Vermeulen, *et al*., 2012). However, there is some information to provide that packaging for certain food products, such as vegetables and meat are of minor importance to GHGEs (Vermeulen, *et al*., 2012) and this coupled with the common practice of recycling packaging in many countries does confirm the previous point. However, pending on type of packaging recycled and the process used, may provide for more GHGEs, for example recycling paper and /or cardboard paper is energy intensive, while recycling glass bottles is less energy intensive (Hilmi, 2019b).

Consumption

Catering and domestic food preparation contributes to GHGEs particularly associated with cooking and refrigeration. In Africa, for example, an estimated 60 percent of energy consumption by small-scale enterprises is used for cooking and baking, and cooking is a much greater proportion of total household energy use in low-income households then countries in high-income contexts. Further, with the expected rise in incomes and the related switching to domestic cooking fuels, emissions are estimated to rise (Vermeulen, *et al*., 2012). In China, for example, the switch from biomass fuels to commercial fuels, particularly coal-based electricity, increased considerably CO2 emissions, from 152 metric tonnes (Mt) to 284 Mt in 2008 (Vermeulen, *et al*., 2012). Here implementing the three strategies of prevent, reduce and recapture for greening food value chains, may include, for example using solar pans to cook food, using more energy efficient stoves to reduce emissions and averting waste by reusing left over food for another meal.

Food loss and waste

In terms of waste, in particular consumer waste, contribute directly to GHGEs[10], pending on typology of waste provided in landfills and associated management practices. The dumping of waste is the main source of carbon emissions in developing countries (Couth & Trois, 2010), and can also provide contamination of surface and ground water, soil, fauna and flora as well as hazards to human health (ISWA, 2015). Transport, as seen previously, makes a large contribution to GHGEs.

The collection of waste is commonly done by muscle or animal power traction and in some instances by motorized vehicles. This is environmentally sound as the divergence of organic waste, for example from landfills, averts far more carbon emissions than motorized vehicles used for waste collection. Further the reintroduction of materials into food value chains causes a reduction in the emissions of pollutants generated during the production and marketing of food, it reduces the quantity of waste that is destined to landfills and consequently less GHGs are emitted as a lower content of organic material goes into landfills (GIZ, 2011a). Much of the recaptured organic matter is redirected to composting and/or animal feed markets. In some instances, organic matter can be transformed into biogas also (GIZ, 2011b). This reintroduction of these 'secondary raw materials' are provided with a lower energy rate, thus lower energy consumption, reduced emissions and primary raw materials are not used (GIZ, 2011b). Overall, this tends to provide a smaller carbon footprint to waste channels.

[10] About 8 to 10 percent of total anthropogenic GHGEs correspond to food loss and waste, which comprises 25 to 30 percent of global food production (Rosenzweig *et al*., 2020)

All such aspects of making a food value chain green and less-carbon intensive will have economic, social and cultural aspects which will need to be considered. Using as an example recapturing value from waste (valorization) through recycling processes, for example, requires the characterization of waste, sorting waste, grading waste, and eventually reusing and recycling the recaptured value. These activities will have economic, social and cultural connotations, beyond the inherent environmental and low-carbon aspect of such operations (Hilmi, 2019b). Recapturing value from waste offers numerous and diverse business opportunities that are usually fulfilled by private sector operators working, usually but not always, in poorer (informal) markets, BOP markets, with their micro-business enterprise operations. However, such business opportunities, it has been found, are also in the spectrum of more formal small, medium and large enterprises. The recapture of value from waste offers numerous opportunities also at community level, for example in terms of increased opportunities for employment and earning income. In some instances, such work is conducted, based on social and cultural associations, where valorization has been an integral part of social and cultural livelihoods. In many communities the world over numerous people are already employed in this area of the food sector, but work in indecent conditions, within hazardous environments and tend to earn very low incomes, even though in some instances what is earned is well above the minimum legal wage (Hilmi,2019b).

Most recycling and valorization of waste provides for social and economic opportunities and social and economic value. The economic value is not just per se, but also, for example, provides for job creation as well as providing other opportunities (UNEP,2011b). Some of these opportunities are for example such aspects as a growth in resource markets as natural resources are becoming scarce and the emergence of new and innovative technologies(UNEP,2011b). The benefits of such recycling and valorization need to consider natural resource and energy saving, creation of new businesses and jobs, potential reuse of food for consumer and animal consumption, compost production, energy produced from waste, reduced GHGEs as well as contributing to equity and poverty eradication (UNEP,2011b).

Commonly it is thought that recapturing value from waste, pending on the value found in the waste, is a simple cost-benefit analysis approach that can provide more benefits than costs. However, it is not only the economic aspects that need to be considered in the cost-benefit analysis, but also and importantly the environmental costs as well as the social costs and the consequent social and environmental benefits in recapturing value from waste. In some instances, for example, it may be found that recapturing value from waste may have only economic (income) and social (employment) benefits, with little environmental benefits. In other instances, it may be that there are far more environmental and social benefits than economic (Hilmi,2019b). Consequently, in attempts to make food value chains greener and thus more climate-sensitive, the economic, social and cultural aspects of climate smarting need to be considered. There may be cases where trade-offs will have to be made between, for example climate mitigation and employment, as possibly changes to foster climate change mitigation may impinge on employment.

Findings

The green food value chain development approach provides for a step by step process and defines a flexible and adaptable method to green and climate smart food value chains. This process as found in Box 2 is ‘supported’ by three main greening strategies as found in Box 1 of prevention, reduction and recapturing. Interestingly what emerged from this research was that other factors needed also to be considered, alongside those provided previously in the green food value chain development approach. These, as found in this research, can further facilitate and enhance the climate smarting of green food value chains from rural to urban areas at the local level. The factors found were the need for strengthening rural-urban linkages, providing for partnerships in terms of governance, coordination and regulation, investments and infrastructure, support services, agricultural technologies, providing for an enabling environment and assessing, monitoring and evaluation.

Strengthening rural-urban linkages

Linkages and partnerships between rural and urban areas and between urban and rural areas are very diverse in nature, scale and are site specific. Such linkages, commonly involve, for example flows of produce, finance, waste and information, the 'channels' in which they occur and the physical and non-physical (digital) facilities in which they occur, including the spatial aspect, in other words where do they occur in topographical, distance and time concerns. Such linkages and partnerships also include social relationships, for example among intermediaries (farmers, traders, processors, retailers), how they are linked together via relational aspects (contract farming, vertical integration, etc.,), and transport and communication technologies. Linkages and partnerships also involve environmental services and can also be cross-sectorial, for example between the agricultural and the service sectors.

Commonly small and large towns and cities have traditionally dependent on rural areas for food, potable water, environmental services and raw materials. At the same time though, rural areas have commonly relied on urban areas for such matters as access to markets, employment and services such as health care, for example. The clear changes that have occurred and are occurring in food systems has led to a stronger dependence of agriculture on urban goods and services and vice versa. National food systems supply 80 to 90 percent of food consumed in developing regions, with only 10 to 20 percent from importation (Reardon, 2016) and thus in this context, a territorial perspective creates a critical lens for analysis, underpinning policy transformation and implementation (IFAD, 2016). To supply increased volumes of food, food supply systems have to reach out geographically, penetrating further into rural areas and deeply affecting farmers and other rural enterprises in food systems, including wholesalers, transporters, processors and input suppliers as well as the millions of rural wage earners working for them (Reardon, 2016).

Specific actions at the rural-urban interface can help improve the conditions and outcomes of the participation of smallholder farmers and of households and small- and medium-entrepreneurs. It can also help to ensure the availability of a diversity of retail choice to the urban consumer in the interests of both the consumer and local producers (Berdegué *et al*, 2014). More closely linked, and in many cases shorter, food supply systems – supported by territorial ecosystem governance approaches – will provide wider opportunities to smallholders, linking producers and consumers from urban and rural areas to markets, and contributing to more sustainable and inclusive modalities of food production and consumption (IFAD, 2016) that provide for low-carbon development that is also resilient. Short food supply systems hold the potential not only for greater conscious planning of the relationship between supply and demand, but also for reorganising the food system so that value distribution becomes more equal, with higher incomes for small-scale producers, for example.

Partnerships for coordination, regulation and governance

Coordination in food systems show that traditional food systems have a relatively short food supply system, commercial relationships largely take place on a spot or cash market, implying loose connections between the segments of the food supply system. In fact, farmers are simultaneously producer, processor and trader of their produce in a traditional food system, as there are relatively few processing and food retail actors in addition to the primary producers (UNEP, 2016).

Modern food systems are characterized by specialization and subdivision of activities, and such features increase the length of the food supply system, including specialized companies in delivering inputs such as seed, fertilizers, machinery and feed at farm level, and several stages of processing and trade (distribution, wholesale, retail). Coordination of all the activities of the specialized actors in such a system is typically based on contracts and standards (of measurement, quality, etc.) to save time and transaction costs. The vertical integration of activities is also a way to reduce transaction costs and business risk. The latter effectively means a shortening of the food supply system as a company (partly) owns and controls a downstream (inputs) or upstream (distribution or retail) activity in the food supply system. Modern food systems are characterized by institutional arrangements governing or coordinating economic relations between segments and transacting parties using procurement systems such as contracts and private standard requirements of quality and safety. Modern procurement systems also include the use of dedicated wholesalers and logistics firms (elements of a transformed wholesale and logistics sector) who contract with retail chains downstream and with farmers or traders upstream (UNEP, 2016).

The coordination mechanism in the food system is key in explaining the governance and power relations in a system as those who set the conditions for contracts and/or the standard requirements determine the playing field for the various actors in the food system.

Food supply systems are more and more being driven by consumer demand and preferences, which are heavily influenced by food marketing and media, fuelled by income increases and urbanization, both affecting dietary and lifestyle patterns. This is key in understanding the governance changes of the food system. These changes provide fertile ground for modern food retail formats whereas the increasing demand for processed and differentiated products has expanded opportunities for the food industry to increase its scale and scope of production. As well as an increasing food demand in volume and variety, the emergence of new technologies and government policies are two additional important drivers of consolidation. Implications of consolidation trends in food retail and processing are related to the supplier-buyer relationships. Most food supply systems are dominated by a few large companies, often multinationals exerting market power (being exerted by procurement, i.e. buyer power), which is illustrated by price setting behaviour and/or determining other business conditions suppliers have to comply with (Reardon, 2016).

To strengthen the potential benefits of rural-urban linkages for the rural and the urban poor, it is important to improve the governance, but from a more holistic societal perspective at the rural-urban interface. This requires to look at three dimensions of governance:

- coordination, as development of the rural-urban interface and of rural-urban linkages is hindered by multiple coordination failures: between policy sectors, between levels of government, between neighbouring local governments, between private and public agents, and between different social actors;
- the challenge of building a collective capacity that cuts across the partial identities of specific public and private actors to identify, express and lead a development agenda of the society as a whole;
- the limited capacities of local governments in rural areas and in small and medium cities, particularly when compared with the higher relative costs of service provision at lower population densities and the difficulties of identifying and mobilizing the sources of comparative advantages of smaller local economies and generally less-resourced societies (Berdegué *et al*, 2014).

From the above, it is clear that a multilevel system of governance with local, regional, national as well as global actors is viable. Multi-stakeholder food system platforms already exist, based on traditional and novel intuitional mechanisms (FAO, 2012) and interactions of local and global food systems should be governed in ways that promote trade and local procurement to improved conditions for small and limited resource farmers in all regions (FAO, 2012).

Investments and infrastructure

To better understand climate-sensitive investments it is first necessary to understand what is primarily required, in terms of investments. For example, what improved transport and storage infrastructure may be needed and then consider how such investments can be made in terms of climate change adaption and mitigation. Cleary investments for adaptation will vary considerably from those of mitigation. For example, investing in solar powered storage facilities, mitigation, will have differing connotations from investing in storage facilities that are more prone to withstand climate variabilities and its extremes, adaptation. Overall though it is useful to categorize adaptation and mitigation investments in terms of how they change the estimated and projected investments needed in terms of the investment amount, when investments are needed and the type of investments required. This, not only implies estimating the additional costs of adaptation and mitigation imposes on investments, but also what will be the future value of such investments in terms of adapting and mitigating climate change if such investments will provide the required outcomes. For example, some investments in wholesale market infrastructure within a city to withstand climate extremes, may have been miscalculated, based on unreliable estimations of future scenarios of climate change, this impinging heavily on the investments made. Moreover, such market infrastructure may have been developed with the underestimation of its mitigation capacity, by using, for example current high efficiency fuel consumption technologies. Consequently, ascertaining and carefully reviewing investment plans to ascertain their real future value is essential.

Other aspects of investments also need to be considered such as providing an enabling environment for investments that encourages and promotes investments that can support low-carbon development. Commonly a sound investment environment, needs to be accompanied with a good regularity environment at all levels of administration, especially at the local level that can guide and target investments in food systems that are not only required for enhancing the efficiency and effectiveness of food systems, but attempt to at the same time to be green and focused on low-carbon investment initiatives.

Further investments in improved low-carbon technologies for harvesting, processing, storage, distribution, and logistics are also necessary. Moreover, investments are also required in institutions that can underpin any technical intervention to manage interactions between food systems and climate change and such key investments include: management and extension of knowledge and information at all levels, financial services, input and output markets, including markets for carbon and other environmental services (Vermeulen *et al*., 2012).

There is however evidence, as seen previously, that such investments will need to be inclusive and consider the poor and vulnerable who live and operate in the BOP and not only foster a low carbon development pathway and consequently cannot be driven from the private sector perspective alone. Thus, investments pending on their nature, will also require public sector interventions. For example, major infrastructure works on the transport infrastructure which makes it more prone to cater to climate variabilities will undoubtedly require public direct expenditure, while modernizing storage infrastructure, may be provided with public and private partnerships.

Support services

As mentioned previously, a food system is composed of many systems within, such as farming, distribution and consumption systems, that are well documented in terms of what they do, who provides them, etc. There are also systems, though, that ‘flow into’, ‘flow out of’ and ‘flow in parallel’ to the food system. For example, input systems flow into the food system providing fertilizer and pesticides at the farm production level and contribute to farming systems operations as input suppliers of packaging flow into the processing level of the food system. These ‘inflow’ systems also contribute to GHGEs and need to be taken into consideration. However some of the systems that are not very often considered in climate smarting food value chains are ‘parallel systems’ that derive, depend and operate in parallel to food value chains: for example waste streams[11] that develop from such food value chains. Such waste streams convey waste into fully operational and mostly informal, ‘shadow waste systems’ that use such waste for mainly economic, but also social reasons, contributing usually, but not always, to the reduction of GHGEs and other environmental impacts.

Support service systems, for example like finance and extension, all flow into food value chains and can play a major role in supporting climate smarting. For example, extension services that advise and provide training on climate smart agricultural techniques at farm production level, can contribute significantly to climate smarting. Further, financial services, and related finance can play yet another important role in climate smarting, as for example, loans can be provided on obtaining investments that provide for climate smart outcomes, such loans being pegged to carbon markets.

[11] A waste stream is the popularly known term for defining organized and coordinated systems that deal with waste deriving from food system activities. However, waste streams are also sometimes referred to as waste channels and also reverse channels (Hilmi,2019b)

Agricultural technologies

The amount and number of climate smart food technologies that can contribute to climate smarting food value chains are numerous. These range from producing farm inputs more efficiently, to more carbon neutral agricultural power and equipment, to recycled packaging materials to more savvy food waste disposal technologies. Technologies for mitigation seek to reduce sources of GHGEs via for example more efficient transport technologies, and 'sinks' for carbon capture, storage and sequestration, while adaptation technologies seek to tender to counteract climate variability, via for example floodgates. However, whatever the technologies be for adaptation and mitigation, they need to be considered in terms of their effectiveness, relative cost, benefits, barriers to implementation, feasibility of implementation, scale of implementation, and importantly applicability to local conditions, and how such technologies can be marketed.

Commonly though, all such technologies, more often than not are driven by an energy source that needs to be available, accessible, affordable, reliable and durable. Consequently, given the need for adequate modern energy at all stages of the food supply system, ensuring energy security matters in developing green climate smart food value chains. This can be done either directly, through the increased use of renewable energy or indirectly, through measures to increase energy efficiency. However, scaling - up renewable energy and energy efficiency measures, optimizing resource efficiency along with clean technology transfer presents a key opportunity to enhance the emission reduction potential and boost resilience.

An enabling environment

An enabling environment can be defined in broad terms as a set of interrelated conditions: the policy, legal, and regulatory framework; governance and institutions; physical security; the social and cultural context of business; macroeconomic policies; access of firms to financial and business services and the availability of physical and social infrastructure services related to firms (FAO, 2013c). A healthy business environment is an essential and basic component for growth and poverty reduction in a country. Inappropriate competition, regulation, taxation, instability and lack of voice stifle entrepreneurial activities, both domestic and foreign, create barriers for investments and favour the informal sector. Reform is an essential part of growth as this enables businesses to change behaviour, invest more and innovate. However, reform of the enabling environment is far from simple as it influences many levels of an economy, involves a wide range of stakeholders, both in the formal and informal sector and is not a single event, but a process. Reform is primarily a political issue and the public sector and economy commonly take the lead, but also importantly own such reforms.

Commonly policy-making and implementation are primarily seen as the role of government, but other 'players' can contribute to creating and ameliorating a favourable business environment. The other players are:

- Local and district government authorities: they are at local level and have an important role in setting conditions in which agri-enterprises operate;
- Private sector organizations: organizations such as private firms, trade federations, producer organizations, etc., can advocate and seek policy reform;
- Political parties: these can be supported and in turn can support change and reform in the business environment;
- Ministries: for example, trade and industry ministries, at central, regional or provincial level can have an effect on the enabling environment and can help change and reform it;
- Other organizations that can also help can be non-governmental organizations (NGOs) research institutions, business development services (BDSs), along with worker organizations and local, community organizations.

In the context of the enabling environment policies, reforms are enacted commonly to address problems and needs that may be faced by businesses in general and in this case in particular by food value chain actors. This means a process were collaboration needs to be sought from the private sector and from all levels of government. Policies seek to achieve a particular set of objectives, with a series of related decisions and importantly need to be considered as an on-going process and not a one-off matter. This means they need to be sustained over time and capacity needs to be developed to enable continuous monitoring and evaluation of the reform process, as well as its impact on the enabling environment. Thus the reform process will need to be seen as a cycle based on steps: diagnostic, design, implementation and evaluation. Importantly the enabling environment needs to be seen from four different levels: the regional, national, and particularly important the sub-national and local levels. A particular emphasis is also required in the implementation of reforms.

It has been amply demonstrated that state-business relationships (SBRs) or what is also termed as public-private dialogue (PPD) plays a key role in promoting and implementing enabling environment reforms (Bannock, 2006). Dialogue between the private sector and the public sector needs to be set with a small range of issues initially and the issues raised need to be those that face the least political resistance to change, for example business registration is less politically impinged then land registration. (Bannock, 2006). Reforms need to occur at all levels of the public sector: central, state, provincial and local (municipal) and importantly require active participation from the various levels of the public sector. Sub-national institutions play an important role in the functioning of the enabling environment. National regulatory policies may influence or affect, for example investments, but post-investment operations are influenced by other levels of government having legal authority over such operational activities- principally those at municipal level (IFC, 2006). It is at this level that local authorities have the regulatory role and provide the functional enabling environment for enterprises. Being at the local level also enables more dialogue and consultations between enterprises and the public sector, as well as improved recognition and diversity of the local business environment.

Local level authorities commonly provide a number of regulations: Registration, licensing and restrictions on enterprises; operational permissions, such as transportation; safety requirements and standards, etc. These are all important enabling factors for greening food value chains. Local authorities are needed to regulate, but are also there to provide services that enable green low carbon growth and competitiveness. The two aspects of regulation and providing facilitating services to enterprises may seem conflicting, but can be mediated by regulatory simplification processes. Simplification is not only streamlining regulatory processes by eliminating mechanical regulatory processes or steps, but importantly means changing attitudes and moving toward a service concept, where food value chain actors are seen as clients that undertake economic activities not only for their own benefit, but for that of the local community also. This viewpoint is distinctly different from an attitude where enterprises need 'permission' for any economic activity or any other activity related to it (IFC, 2006).

Local authorities can provide a critical role in the reform process. They can be the initiators of needed reforms. Local authorities can also be pivotal in information collection needed for decision-making regarding the enabling environment. For example, information can be collected from food value chain actors and such inputs can be used in the reform process. Importantly local authorities require a strong commitment and visible support from the political and senior official levels of the local authority (IFC, 2006). This is essential not only for implementing reforms, but also for being the initiators of reforms.

Consequently, the public sector and the public economy, especially at local level, has a new role to play in greening food value chains. Local administrations play a key role in this as they are closely linked to territories and thus can play a vital role in providing advice as well as support to national governments as well as development interventions. The public sector can play an important role in mobilizing partnerships with the private and social sectors and using local institutions. The intent is to raise awareness and not force greening of food value chains on to its actors, but intervene in local economies with ad-hoc policies.

Assessing, monitoring and evaluation

Assessing concerns enabling a better understanding of a situation in a defined context of interest. For example, carrying out a carbon footprint exercise for a wheat value chain. Monitoring is an ongoing exercise that attempts to better understand a defined situation, with the use of baseline data and indicators, related to previously set targets. For example, monitoring a wheat value chain for its carbon footprint within a BOP context to ascertain if the intended objectives and related activities of reducing GHGEs (mitigation) are in line with the expected outcomes. Evaluation considers primarily the outcomes and impacts of predefined actions within a defined situation. For example, evaluating actions taken and their outcomes and impacts in reducing GHGEs in a wheat value chain. Assessing, monitoring and evaluating are inherent for both mitigation and adaptation necessities related to greening food value chains.

In terms of prevention, reduction and recapturing strategies for mitigation, assessing, monitoring and evaluation, for example, can be provided by carbon foot printing, which enables a more in-depth assessment. Such an assessment takes more time and budget, than a hotspots analysis, but can provide far more data and information. But the resulting information can be used, for example, for developing indicators and targets, used for monitoring and evaluation. The exercise of carbon foot printing measures the sources of and the GHGEs related to a single activity, a number of activities or a product within a food value chain. It attempts to measure, and consequently better understand, the direct and indirect GHGEs, expressed in kilograms of CO2 equivalents, provided by activities all along the food value chain from pre-farm production to waste disposal. Direct sources of GHGEs are usually more easy to define, then sources of indirect GHGEs. A carbon footprint measures the sources and amounts of GHGEs produced from the inception of a food product until the product's life's end. For example, the carbon footprint of a wheat value chain is an estimate of all the direct and indirect emissions caused by the value chain of wheat (pre-production, production post-production, consumption, waste, etc.) within the life cycle (cradle-to-grave analysis) of the wheat product. Conducting such an exercise will also provide indications of where within the wheat value chain emission 'hotspots' occur and thus indicate where actions will have to be taken within the supply system to curtail such emissions and thus attempt to mitigate GHGEs. This 'tool' can thus enable a better understanding of where within a food value chain emission hotspots are, what is causing them and can provide for target reduction objectives in terms of GHGEs for evaluation purposes as well as indicators useful for monitoring.

In terms of prevention, reduction and recapturing strategies for adaptation, assessing, monitoring and evaluation can be provided by attempting to forecast realistic outcomes of climate change and using early warning systems (EWS). This will provide, for example, to better understand what effects climate change may have in the future, thus enabling a better understanding (assessment), set indicators as to enable the monitoring of developments and strategies put in place to adapt to climate change and provide for targets so as to enable evaluation of the results.

A climate change monitoring system integrates satellite observations, ground-based data and forecast models to monitor and forecast changes in the weather and climate. A historical record of spot measurements is built up over time which provides the data to enable statistical analysis and the identification of mean values, trends and variations (UNEP, 2011c). Systematic observation of the climate system is usually carried out by national meteorological centres and other specialised bodies. They take measurements and make observations at standard present times and places, monitoring atmosphere, ocean and terrestrial systems (UNEP, 2011c). However local populations do have traditional forecasting methodologies that can provide key insights into local climate conditions and vulnerabilities that will be essential for effective adaptation. Although a traditional practice, forecasting with ancestral bio-indicators can be considered an adaptation technology because studies show that they are complementary to climate predictions issued by national meteorological services (UNEP, 2011c). In many cases, bio-indicators are more effective for local-level response and adaptation strategies as they provide a more immediate diagnosis than meteorological warnings issues by centralised state entities and are also more adapted to predicting conditions at the local level (UNEP, 2011c).

Such bio-indicators have been developed over years of observation and experience and bio-indicators form an essential part of community strategies for disaster risk reduction and climate change adaptation. Ancestral bio-indicators enable farmers to maintain productive farming practices and even to take advantage of changes in climate where this leads to longer periods of suitable weather for crop cultivation, or where they are able to adjust crop type to benefit from new climate conditions (UNEP, 2011c). Traditional forecasting methodologies incorporate local observations of climatic and other environmental changes or bio-indicators into social organization to provide an early warning mechanism for hydro-meteorological phenomena that appear suddenly or over time(UNEP, 2011c). Environmental bio-indicators of climate change include: changes in the behaviour of animals (for example migration and mating seasons), of plants (such as changes in hydrological tolerance, flowing periods and changes in ecosystem composition) and of weather conditions (such as longer, drier periods, increased frequency of cold periods) (UNEP, 2011c). Rural farmers have learned to observe local bio-indicators as a basis for making strategic decisions about their agricultural production. One such strategy is the observation of certain bio-indicators several months before sowing and during the crop growth cycle in order to make weather forecasts and predictions and adjust planting and cultivation activities accordingly (UNEP, 2011c).

Due to the complexity of global climate and weather systems and the fact that understanding is based on modelling using historical data, the regular measurements of specific variables provided by climate monitoring systems is essential for developing EWSs (UNEP, 2011c). A EWS is a set of coordinated procedures through which information on foreseeable hazards is collected and processed to warn of the possible occurrence of a natural phenomenon that could cause disasters. Early warning system (EWS) technology designed as a climate change adaptation strategy must therefore be capable of forecasting a number of climatic events that correspond to different time scales:

- Three to four months of advance warning of a drought;
- Two to three weeks of advance warning of freezing weather conditions and monsoons;
- A few hours of advance warning of torrential rain, hail and floods (UNEP, 2011c).

The EWS technology contributes to the climate change adaptation and risk reduction process by improving the capacity of communities to forecast, prepare for and respond to extreme weather events and thereby minimise damage to infrastructure and social and economic impacts, such as loss of livelihoods (UNEP, 2011c).

Conclusions

The lessons learnt from this research in climate smarting local food systems from rural to peri-urban to urban, are numerous. These are as follows:

- The first lesson learnt is that a systemic and holistic approach is required, where numerous factors work in synergy. For example, the green food value chain strategies of prevention, reduction and recapturing need to be planned and implemented being informed by a climate change monitoring system, supported by an enabling environment and support services;
- The second lesson learnt is that a local level climate monitoring systems is important. This system being connected, of course to regional, national and global climate monitoring systems. But importantly, though, the information from such a system needs to be communicated in a timely and understandable manner to all food value chain stakeholders. This not only for short-term future periods, but also for future long term periods, that for example can enable a better assessment, diagnosis and estimation of required investments that are climate smart;
- The third lesson learnt is that investments, for example in infrastructure, need to consider and categorize adaptation and mitigation in terms of how they change the estimated and projected investments in terms of the investment amount, when investments are needed and the type of investments required. For example, investments required by the private sector as well as the long term returns on investments that are commonly found, need support from other parts of the economy as markets do not provide for the full incentives for such investments;

- The fourth lesson learnt is that partnerships need to be provided not just between local food value chains stakeholders but at multiple levels. For example, partnerships between private operators in the food value chain, be they rural, peri-urban, urban, regional, national, and international, public stakeholders (local, regional and national), non-governmental and inter-governmental and support services (public, private and non-profit);
- The fifth lesson learnt is that support services play a critical role in climate smarting, be they private, public, non-profit and community based. For example, private finance that motivates low carbon green investments and provided in synergy with community-based extension services;
- The sixth lesson learnt is that ensuring energy security matters in climate smarting food value chains. For example, this can be done via the increased use of renewable energy or via measures to increase energy efficiency;
- The seventh lesson learnt is that an enabling environment is needed, but with a focus at the local level and is motivated, fostered and promoted by local authorities. For example, local authorities can provide for stimulating, enhancing and prizing climate smart behaviours from private sector firms and can act as conduits for partnerships among the various stakeholders in local food value chains as well as among the different levels of administration at regional and national level;
- The eighth lesson learnt is the need for encouraging, motivating and fostering rural and urban linkages. For example, the coordination, regulation and governance of rural to urban food value chains can foster partnerships among stakeholders, but can also enable a shorter, smother and more regular supply of food;
- The ninth lesson learnt is that in terms of climate smarting local value chains, markets cannot do it all alone, as active demand for low-carbon green products are not commonly present, while there is considerable latent demand for low carbon green products. This entails the public sector and public economy intervention so as to provide for where markets do not reach;
- The tenth lesson is that there are some clear indications that public-private and social partnerships are a must: A multi-stakeholder approach and importantly a multi stakeholder platform need to be not just considered, but designed, planned and implemented;
- The eleventh lesson learn is that awareness creation for climate smarting food value chains towards policy-makers with an effective communication strategy is much needed. This will not only raise awareness on the necessities to develop green food value chains, but also bring into the lime light BOP contexts that are commonly 'invisible' and how these do and can contribute to greening practices within food value chains.

Clearly a bottom-up approach to climate smarting, as provided by the green food value chain development, reflects the reality of many contexts found in many developing countries. The BOP has been found to be a great learning school, also from others, for example see Banerjee, A. and Duflo, E. (2012) and Viswanathan *et al*., (2012). The approach needs to be seen from the eyes of practitioners and how such settings require easy to use and practical approaches. Such an approach needs to be seen to provide guidelines for climate smarting and greening food value chains and not specific and detailed actions of what needs to be done, with all the advantages as well as limitations that such an approach can have. Cleary this is the case as climate smarting and greening activities in food value chains is very context and local specific as per the high diversity of BOP contexts found globally as well as, for example local agro-ecological zones. The approach is also dynamic as climate smart greening initiatives and efforts need to keep up with the changing necessities derived from climate change[12].

[12] The findings and lessons learnt from this research have contributed to increasing the knowledge accumulated in the development process of the green food value chain development approach. The approach has accumulated over the period 2012 to 2019, data and information, hence knowledge and know how, from 23 countries: Algeria, Belize, Cameroon, Chad, Egypt, Fiji, Ghana, Grenada, Haiti, Iran, Iraq, Jamaica, Kenya, Liberia, Peru, Solomon Islands, Tanzania, the Gambia, Trinidad and Tobago, Tunisia, Uganda, Vanuatu and Zambia.

Further research

From the research there is evidence to suggest that far more research should be carried out on rural and urban green food value chains development and how mitigation, adaptation and resilience can be provided for (climate smarting). Interestingly from this research what also emerged were other factors that needed to be considered in green food value chain development in the rural and urban context. For example, strengthen of urban and rural urban linkages was found in this research context. However, in differing research contexts, other factors may be found and this could be documented and reported on within the overall approach of green food value chain development. Furthermore, more research could be conducted on green food value chain development in urban areas and how such food supply systems can be made more climate smart. Moreover, food products also go from urban to rural areas and further research could be conducted on green food value chain development within this food supply system and how these can be also made more climate smart.

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