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Climate Smart Agriculture

Beyond the theoretical definition

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Climate Smart Agriculture

Beyond the theoretical definition

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Table of Content

List of Figures

List of Tables

Introduction

1 Research outline

1.1 Framing the analysis

Climate change is likely to have profound global effects on both developed and developing countries: carefully planned mitigation and adaptation measures can reduce negative environmental and social impacts, and yields significant benefits, but decision-makers worldwide still face obstacles when devising interconnected strategies. Historically, mitigation and adaptation have been treated - both in the policy and science domains - as separate instances (De Boer J., 2010) due to their spatial and temporal timescales´ mismatches (Wilbanks & Sathaye, 2007). Whereby mitigation actions were seen in connection to long-term, top-down policy approaches having an impact on global climate, adaptation was mainly concerned with confronting short-term impacts and climatic shocks at a local scale, with a strong focus on developing countries (Klein, et al., 2007a) (Birkmann & von Teichmann, 2010). This policy disconnect has paved the way for the creation of differentiated work streams resulting in detached climate change efforts on the ground, not accounting for existing synergies and possible trade-offs.

Nevertheless, progresses have been made and both the academic and policy communities have long acknowledged that mitigation efforts alone will be insufficient to manage climate change challenges and hence adaptation is not only necessary, but also inevitable (Anderson & Bowes, 2008). Thus, over the last decades, adaptation and mitigation have been increasingly seen as core components of more effective climate change responses (Adger & Winkles, 2007). At the policy level, initial recognition of the importance of adaptation translated into concrete policy actions, e.g. at the COP7 in Marrakech, with the creation of three funds. Following the COP13, adaptation acquired an equal status as mitigation. In the academic realm, this shift was initially reflected in the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (AR4), in which a chapter was dedicated to the interrelationships between mitigation and adaptation. These initial steps were followed by a multitude of researches aiming at better understanding the interplay between these two fields e.g. analysing linkages between climate change adaptation and disaster risk reduction, vulnerability and resilience aspects (Birkmann & von Teichmann, 2010; Cannon & Müller-Mahn, 2010; Eriksen & O´Brien, 2007); explicitly modeling the connections through innovative integrated assessment models (IAMs) (e.g. AD-WITCH; AD-RICE; AD-DICE) analyzing the costs and relative benefits of mitigation and adaptation (Bosello, Carraro, & de Cian, 2010; Agrawala, Bosello, Carraro, & de Cian, 2009; de Bruin, Dellink, & Agrawala, 2009; Agrawala S. , et al., 2010; Agrawala, Matus Kramer, Guillaume , & Sainsbury, 2010; Bosello & Chen, 2010). Later the IPCC in its 5th Assessment Report (AR5) brought this issue a step further clearly affirming that climate change is not only an environmental problem, but it is also a social and economic challenge. In order to be cost-effective, strategies need not only to consider mitigation and adaptation as complementary facets, but they also have to be coupled with sustainable development objectives (i.e. reduction of poverty, improving food access and security, generation of sufficient income) (Klein, et al., 2007; Carraro & Mazzai, 2015). The climate change debate has started to be framed in a sustainable development discourse, and both scientists and decision-makers have made a collective audible call to support strategies that deliver so-called "triple wins" benefits, namely single strategies generating positive impacts along three dimensions: climate change adaptation, mitigation and sustainable development. This supported the development of an array of new concepts, among which, low-carbon development, climate compatible development (CCD), and climate-smart agriculture (CSA) (Denton, et al., 2014; Fisher, 2013). Despite the terminology adopted, all these concepts refer to trajectories that effectively combine climate change adaptation and mitigation to realize the goals of sustainable development aiming to maximize opportunities presented by a low-emissions and more resilient future (Mitchell & Maxwell, 2010). Furthermore, in the context, of a global economic recession coupled with increasing population growth rate and urbanization process, these notions have acquired even more impetus, especially in low and middle-income countries. Cities in those countries are faced with the challenges to develop innovative strategies to improve the living conditions of their citizens, while simultaneously contributing to mitigate climate change, preserving the natural resource base and vital eco-system services. According to the United Nations Populations Fund, the world´s urban population is expected to reach 6.4 billion by 2050, and already by 2030, 60% of the world population will be living in cities (UN Population Fund, 2007). Furthermore (though it cannot be claimed with absolute certainty, since several factors affect these trends such as fertility, life expectancy, and epidemic) these increases will mainly take place in low and middle-income countries[1] (UN-DESA, 2015). Current demographic and urbanization patterns are already posing at risk the resilience of socio-economic and environmental systems in cities, i.e. inadequate infrastructure, overcrowding, fresh nutrient rich food insecurity, and environmental degradation like loss of biodiversity (de Bon, Parrot, & Moustier, 2010). Climate change will place additional stresses on those already living in poverty by worsening living conditions and even making some areas uninhabitable (i.e. increased pollution and warming) (Boyd & Tompkins, 2010). Feeding an increasingly urbanized world in ways that are sustainable, resilient, healthy and fair has become a pressing challenge.[2] Although global food systems have made significant progresses towards increasing/intensifying agricultural production, the number of hungry and malnourished people has hardly reduced (UN-DESA, 2015). Agriculture is still a mainstay of many low and middle-income country economies and forms the basis of millions of people´s livehoods. It both provides and is a threat to ecosystems services as agriculture is one of the most important causes of global warming, as well as a critical sector that will be affected by climate change (FAO, 2011a). Most estimates indicate that climate change is likely to reduce agricultural productivity (i.e. temperature, precipitation, sea level rise and subsequent salinity intrusion) and will affect the stability of food systems. While, rapid population growth and urbanization will further accelerate the demand for higher quantity of quality food, especially of high value foods such as fruits, vegetables, milk, meat and eggs especially in urban areas (FAO, 2011a). Multiple demands are thus being placed upon agriculture in the context of finite natural resources, demographic pressures, the threat of climate change, and the importance of ecological processes and tipping points.

Against, this backdrop, researchers and policymakers have started questioning whether cities are and will be adequately prepared to adapt to the heightened risks associated with climate change, and how will the most vulnerable segments of the society, who already struggle to access food and services, cope against this increasing level of insecurity. The importance and the strong connection between resilience and the sustainability of socio-ecological systems have been under progressively scrutiny, including the need to increase the sustainability of food

[1] When speaking of population projections, it is important to keep in mind that these estimated can vary significantly from one revision to the next. This bears witness to the uncertainties surrounding this variable, and hence the associated food projections (UN-DESA, 2013)

[2] http://www.fao.org/fileadmin/templates/FCIT/Meetings/WUF_7_City_Region_Food_Systems_2014_05_09_Call_to_Action.pdf

systems. More and more attention has been devoted to the potential of CSA strategies (FAO, 2013a; World Bank, 2008) which contrary to traditional agricultural development have the potential to systematically integrate the needed changes of agricultural systems with a climate change and sustainable development perspective (FAO, 2013a). Thus, they can play a key role in helping cities to become more resilient able to respond, resist and recover from changing climate conditions, while simultaneously fostering sustainable development goals. Framed within a population growth, urbanization and food security discourses, the notion has been also funneled towards urban and peri-urban agriculture (UPA) activities, namely farming practices that take place within ('intra-urban') or on the fringe ('peri-urban') of a town, a city, or a metropolis, that grow and raise, process and distribute a diversity of agricultural products from both plants and animals, using human, land and water resources, products, and services found in and around the urban area (World Bank, 2013a: 3). Over the years, UPA has been officially recognized as a strategy to alleviate urban food insecurity and to build more resilient and sustainable cities by providing the vulnerable urban groups with new opportunities for income and employment creation, reducing the "foodprint" and its related energy use, facilitating productive reuse of organic waste, improving water management and creating a better urban living climate (i.e. CO_2 sequestration, maintain and/or enhance biodiversity, reducing the urban heat island (UHI) effect) (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011). Notwithstanding, these emerging theoretical assumptions, considerable challenges remain. Although it is easy to see the theoretical rationale behind focusing on triple-wins strategies, there is still much less clarity on how benefits can be achieved in practice, and what trade-offs might occur between mitigation, adaptation and sustainable development objectives, which at the implementation level might not be as compatible as they may appear at a first theoretical sight (CDKN, 2013, 2012). Many scholars argued that UPA´s growing body of literature suffers from a lack of scientific inquiry, which does not effectively substantiate the assumption made about UPA´s potential role in cities as an efficient climate smart agriculture strategy (e.g. Iaquinta & Drescher, 2000; Lynch, Binns, & Olofin, 2001). Others affirm that urban and peri-urban farming face serious threats to its own sustainability, especially in terms of health and environmental risks (i.e. use of grey water and heavy metal contamination from fuel and oil residues that enter the food chain) (e.g. (IWMI, 2006; de Bon, Parrot, & Moustier, 2010; Cornish & Kielen, 2004; Dubbeling & de Zeeuw, 2011). Many scholars have also questioned UPA´s role in addressing urban food security, claiming that its contribution is overestimated (e.g. Battersby, 2013; Crush, Hovorka, & Tevera, 2010; Frayne, McCordic, & Shilomboleni, 2014; Mkwambisi, Fraser, & Dougill, 2011; Webb, 2011). The analytical picture is further complicated by the conundrum of UPA´s definitions - often re-adapted on an ad-hoc basis - applied with reference to a diverse range of agricultural activities (i.e. crop, livestock, aquaculture) making comparative analyses extremely difficult.

1.2 Objectives, analytical methods and structure

The knowledge base of UPA's triple-wins impacts appears to be rather fragmented and mixed. From a theoretical perspective, a considerable number of studies can be found discussing UPA´s potential and effectiveness as climate-smart strategy (e.g. (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011; Dubbeling & de Zeeuw, 2011; FAO, 2012a; Gerster-Bentaya, 2013; Lwasa et al., 2014; World Bank, 2013a). However, only a limited number of studies provides sounded analyses and data (e.g. Danso, Drechsel, Akinbolu, & Gyiele, 2003; Padgham, Jabbour, & Dietrich), including limited evidence assessing UPA´s triple-wins impacts on the ground, especially in low and middle-income countries. This research aims to contribute to fill these knowledge gaps and to add to the ongoing debate about UPA´s effectiveness as a climate-smart strategy in low and middle-income countries (e.g. Wilbanks & Sathaye, 2007; Bizikova, Robinson, & Cohen, 2007; Swart, Robinson, & Cohen, 2003; Serban, Belton, Chalabi, Mechler, & Puig, 2014; CDKN, 2014). Accordingly, this research focuses on the practical investigation of UPA´s triple-wins impacts on the ground to gain a better understanding of whether and to which extend these farming practices can support the building of more resilient and sustainable cities as well as to gather targeted knowledge about possible differences existing among cities located in different low and middle-income countries. Overall, the research builds upon a climate-smart/climate compatible analytical rationale, including climate change mitigation, adaptation and sustainable development aspects. Building upon existing literature and secondary data sources, the analysis conducted is based on a multi-methods research design comprising of qualitative content analysis coupled with a case study research approach, and of a multi-criteria decision analysis evaluation process, the PROMETHEE II. First of all, in order to select a set of representative case studies and related triple-wins evaluation criteria an extended literature review was carried out, which includes the revision of 130 documents. On the basis of this literature review, the triple-wins indicators were then selected trying to achieve the best estimation of the benefits that UPA can generate in urban contexts and to gather a better understanding of UPA´s effectiveness as a climate-smart strategy, based on data already available for the selected cities:

- **Mitigation**: GHG emissions reduction, carbon sequestration, reduction of landfill volume, and of chemical fertilizers/pesticides;
- **Adaptation:** use wastewater for irrigation, reduction of the urban heat island effect and of incidences of floods/erosions;
- **Sustainable development:** food security, improved diets and nutrition, reduction of food prices, and increasing inclusion of marginalized groups into economic activities.

Secondly, the multi-criteria decision analysis method PROMETHEE II was applied enabling the classification (outranking) of nine selected case studies, three for each world region, Africa, Latin America and Asia. The PROMETHEE II multi-criteria decision making analytical method well adapts to the analysis of a problem where a finite number of alternatives are to be ranked considering several and sometimes-conflicting criteria, and in this research it also exemplifies a novel application, being it tested and applied "*ex-post*" as an evaluation tool, enabling the comparison and classification of the different case studies, accounting for the a triple-wins perspective.

The structure of the research is as follows: Chapter 2 presents a general overview of the evolution of climate change policies and researches towards an integrated triple-wins perspective. Chapter 3 looks into the economic, environmental and social causes, which have led to the renew attention towards the application of the triple-wins concept to urban and peri-urban farming practices. In Chapter 4 the theoretical framework of the applied multi-methods research design and the specific analytical steps and processes applied are unfolded. A description of each case study and the process applied for the selection are presented in Chapter 5. The multi-criteria decision-making approach PROMETHEE II including the identification and selection of indicators are described in Chapter 6. While, Chapter 7 discusses and interprets the results of the PROMETHEE II analysis, and in Chapter 8 the main conclusions are presented.

Theoretical Foundations for Analysis

2 Climate Change and Sustainable Development

2.1 The inception: the mitigation - adaptation disconnect

It has been long recognized and recently reiterated by the IPCC AR5 (IPCC, 2014, WG3: 9) and by the consultation outcomes of the COP21 that it is fundamental to meet the global goal of keeping the mean surface temperature increase below 2°C or 1.5°C relative to pre-industrial level.[3] Nevertheless, it has been also acknowledged that even if this limit is kept, substantial impacts on society, human health, and ecosystems are projected to occur. Carefully planned mitigation and adaptation measures can reduce negative environmental impacts, and yields significant benefits. However, decision-makers worldwide still face several obstacles when trying to devise interconnected climate change strategies.

Mitigation and adaptation have been historically analyzed along two distinct work streams: with mitigation research characterizes by a global systemic approach exemplified in 'top-down' aggregate modeling focusing strongly on technological and economic issues (Ayers & Huq, 2009) encompassing efficient use of energy and of renewable energy sources, and carbon sequestration through land use management (i.e. reforestation, afforestation) (Boyd & Tompkins, 2010). On the other hand, adaptation researches emphasize place-based factors, sharing the analytical approach of development and disaster risk-reduction studies, with a special focus on the water, building and health sectors (Klein, et al., 2007). They focus on reducing existing vulnerabilities to past and present stressors, building adaptive capacity, long-term resilience[4] (e.g Ensor & Berger, 2010; Malik & Smith, 2012), and hence aiming to minimize immediate- and short-term impacts of climate trends and shocks, primarily in developing countries (e.g. Klein, et al., 2007; Birkmann & von Teichmann, 2010). This has resulted in mitigation and adaptation being separated in terms of spatial, temporal and socio-economic scales and analytical sectors (Wilbanks & Sathaye, 2007).

[3] Source: http://newsroom.unfccc.int/unfccc-newsroom/finale-cop21/

[4] Resilience refers to building the capacity of society – whether individuals or communities - to recover after any climate-related shocks (Fisher, 2013).

Table 2.1: The mitigation – adaptation disconnect

	Mitigation	Adaptation
Spatial scale	Global benefits & international focus	National issues primary local benefits
Time scale	Long-term focus & effects	Possible short-term focus on vulnerability[5] reduction
Sectors	Energy; transportation; waste management; industrial production sectors	Water; health; building sectors

Source: Adapted from: IPCC AR5 Summary for Policymakers, 2014.

Mitigation researches have been perceived to be easier manageable due to their global scale, while adaptation measures have tend to be considered as local matters (i.e. it can be both anticipatory or reactive, and it often depends on a mosaic of local circumstances) concerns of national governments, and therefore difficult to quantify in terms of global benefits. This has resulted in a sort of dominance of mitigation both in the academic realm and on the international policy agenda. Correspondingly, less attention has been paid to adaptation, which has evolved in its narrowest sense (Ayers & Huq, 2009; Pielke, Prins, & Sarewitz, 2007; Wilbanks & Sathaye, 2007; Moser, 2011) leading to a scientific knowledge being relatively sparse and disaggregated across countries.

Against this background, global discourse has thus evolved in order to improve the understanding of the short- and long-terms synergies and tradeoffs between climate change mitigation and adaptation objectives. Over the last two decades, increasingly attention has been given to explore the inter-relationships between adaptation and mitigation (e.g. Tompkins, et al., 2013; Preston, Westaway, & Yuen, 2011). The initial recognition of the importance of adaptation issues translated into concrete policy actions at the COP7 in Marrakech (2001), with the creation of three funds for adaptation actions. Following, in 2007, at the COP13 in Bali adaptation was finally brought onto equal status as mitigation (Klein, et al., 2007), and was presented as

[5] Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change. The term 'vulnerability' may therefore refer to the vulnerable system itself, e.g., low-lying islands or coastal cities; the impact to this system, e.g., flooding of coastal cities and agricultural lands or forced migration; or the mechanism causing these impacts, e.g., disintegration of the West Antarctic ice sheet (IPCC, 2007a).

one of the four building blocks of the negotiations process, together with mitigation, technology, cooperation and finance (Klein, et al., 2007). In the scientific domain, the IPCC 4th Assessment Report (AR4) introduced - for the first time - a chapter dedicated to the interrelationships between mitigation and adaptation (e.g. Denton, et al., 2014; Klein, et al., 2007). The IPCC AR5 WG II further stressed the importance of interlinkages by considering synergies and tradeoffs between mitigation and adaptation when planning climate change policy (e.g. Denton, et al., 2014; Klein, et al., 2007). The recognition of the need to better understand and explore trade-offs between these two climate change responses, generated an array of innovative research streams (e.g. Clark, Crutzen, & Schellnhuber, 2004; Dang, Michaelowa, & Tuan, 2003) aiming at answering questions such as: how much adaptation and mitigation would be optimal, when, and in which combination? When and where is it best to invest in adaptation, and when and where in mitigation? What is the potential for creating synergies between the two responses? How will their costs and effectiveness vary over time? Accordingly, science and policy have moved beyond the initial disconnection paying progressively attention to the feasibility, and effectiveness of integrating mitigation and adaptation strategies, assessing the costs and benefits for adopting integrated approaches in response to climate change (e.g. Wilbanks & Sathaye, 2007; Klein, et al., 2007; Parry, 2009). The initial underpinning rationale was to quantify economic impacts as well as short and long-term effects, so that the costs of addressing climate change impacts could be reduced and co-benefits increased. Research efforts focused on analysing low-emission or clean energy pathways linking climate change adaptation to disaster risk reduction, and on vulnerability and resilience aspects (e.g. Birkmann & von Teichmann, 2010; Cannon & Müller-Mahn, 2010; Eriksen & O´Brien, 2007). This resulted into researches mainstreaming mitigation and adaptation into development planning and implementation studies (e.g. Chuku, 2010; Klein, et al., 2007a; Klein, et al., 2007b; Kok, Metz, Verhagen, & van Rooijen, 2008). Concurrently, integrated assessment models (IAMs) (e.g. AD-WITCH; AD-RICE; AD-DICE) developed, explicitly analyzing costs and relative benefits between climate change mitigation and adaptation issues (e.g. (Bosello, Carraro, & de Cian, 2010; Agrawala S. , Bosello, Carraro, & de Cian, 2009; de Bruin, Dellink, & Agrawala, 2009; Bosello & Chen, 2010). These models yielded interesting results on time composition of the optimal climate change strategy, and reinforced the assumption that mitigation and adaptation are strategic complements and need to be part of cost-efficient climate change strategies (Bosello, Carraro, & de Cian, 2010; de Bruin, Dellink, & Agrawala, 2009; Agrawala S. , et al., 2010). Further studies started analyzing examples of the linkages between adaptation and mitigation both in developed and developing countries, including, among others, urban planning (e.g. (Laukkonen, Blanco, Lenhart, Keiner, Cavric, & Kinuthua-Njenga, 2009; Revi, 2008) forestry (e.g. King, 2011), agriculture (e.g. Smith & Olesen, 2010), water (e.g. Bhandari, Bhadwal, & Kelkar, 2007), and energy (e.g. Allcott & Greenstone, 2012). They demonstrated that effective implementation of mitigation and long-term adaptation strategies can generate opportunities and produce economic, environmental and social benefits: for instance, conservation agriculture practices (in some regions) can reduce greenhouse gas emissions from soils or fertilizers as well as the vulnerability of crops to rainfall variability (Locatelli, Pavageau, Pramova, & Di Gregorio, 2015). Similar complex interconnections applied to others sectors where mitigation and adaptation activities may clashes without coordinated efforts and a common development vision.

2.2 Mainstreaming sustainable development into climate change

When comprehensively looking at the connection between climate change and sustainable development, one could observe that traditionally these fields have been addressed separately. The lack of connectivity can be attributed to the very different research traditions out of which these two fields developed. The climate change literature is science-driven, based on approaches and analyses that emerged out of the natural sciences (Robinson & Herbert, 2005); while, the sustainable development research evolved around a problem-driven approach, focusing on concerns highly connected to social issues, such as poverty eradication, social inequalities, and environmental degradation affecting human wellbeing (Robinson & Herbert, 2005). However, the importance of integrating mitigation and adaptation strategies, with sustainable development objectives has been increasingly recognized, due also to a enhance knowledge about how these domains interact in dynamic cycles, linked in complex ways that affect socio-economic and technological development pathways (e.g. Munasinghe, Canziani, Davidson, Metz, Parry, & Harisson, 2003). Sustainable development intersects with many of the drivers of climate change, especially regarding energy production and consumption, the ability to mitigate emissions and to adapt to changing environments (Denton, et al., 2014). Adaptation reduces the impact of climate stresses on human and natural systems, mitigation lowers greenhouse gas emissions, and sustainable development critically shapes the carbon emission path and the adaptive capacity of the society (e.g. Bizikova, Robinson, & Cohen, 2007; Metz, Davidson, Bosch, Dave, & Meyer, 2007; Munasinghe, Canziani, Davidson, Metz, Parry, & Harisson, 2003). Similarly, climate change can affect sustainable development objectives, in terms of losses of ecosystem services, challenges to land and water management, negative effects on human health, increasing food insecurity, systemic risks to infrastructures, and to rural livelihoods (e.g. World Bank, 2010a; Adger, et al., 2011). Accordingly, the concept of sustainable development has been progressively mainstreamed into the climate change policy agenda.

Initially, defined by the World Commission on Environment and Development, in the report *Our Common Future,* sustainable defined is referred *"as development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Metz, Davidson, Bosch, Dave, & Meyer, 2007). Since then it has acquired the status of an overarching economic, environmental and social development approach (UNDSD, 2006). At the 2002 World Summit on Sustainable Development, in Johannesburg, governments, private-sector actors, NGOs, and citizens reiterated the importance of sustainable development taking a concrete step in moving the concept toward a more productive exploration of the relationship between economic development and environmental quality (Adger & Winkles, 2007). More recently, the outcomes of the Rio+20 Conference, the *Future We Want,* further underscored the points of intersection between sustainable development and climate change defining the latter *"… as an inevitable and urgent global challenge, with long-term implications for the development goals of countries worldwide…".* [6] Lastly, in September 2015, the United Nations Sustainable Development Summit reinforced the message by adopting the *2030 Agenda for Sustainable Development* comprising of 17 new Sustainable Development Goals (SDGs).[7] Although, these goals still address the root causes of poverty (i.e. social inequality, access to education, health services, energy, and water) they are also directly connected to a climate change discourse. The 2030 Agenda identifies, in its paragraph 14, climate change as one of the greatest challenges of our time and draws attention on its adverse impacts: stronger emphasis than ever before has

[6] Source: https://sustainabledevelopment.un.org/?menu=1300

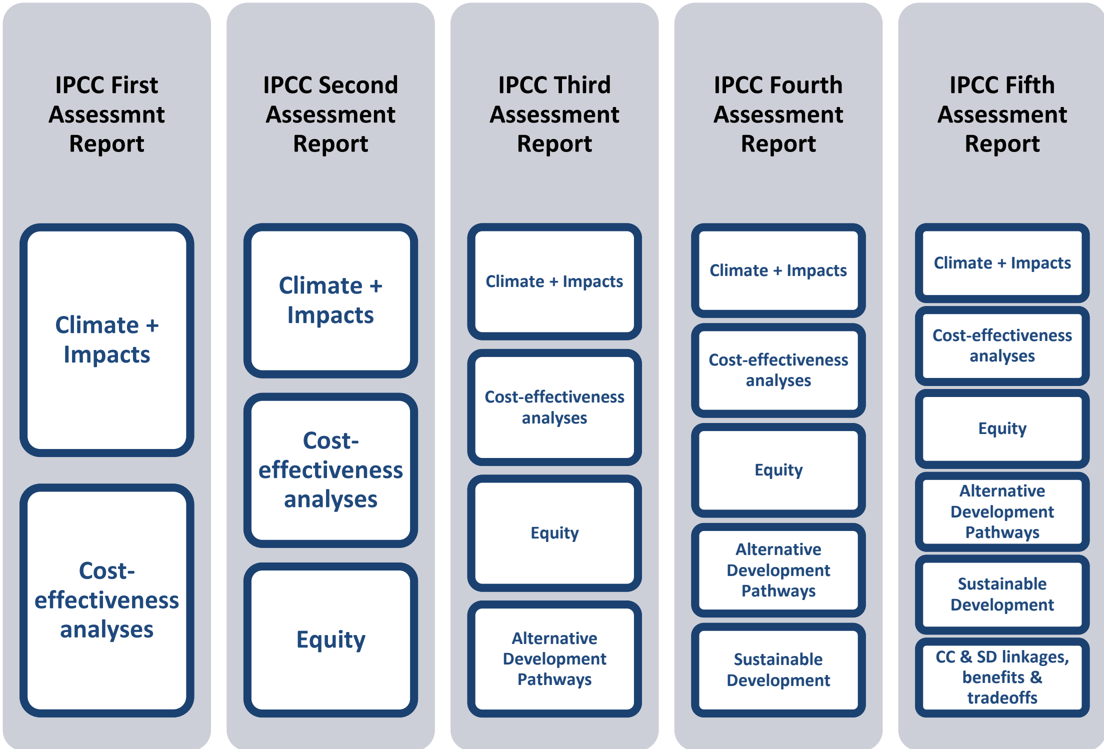
[7] These goals build on the Millennium Development Goals (MDGs) – adopted in 2000 – focusing on issues such as, slashing poverty, hunger, disease, gender inequality and access to water and sanitation that the nations committed to achieving by 2015.

been given to impacts on eco-systems, biodiversity loss, sustainable management of terrestrial and marine resources, and desertification.

Contemporary to the evolution of the political backdrop, sustainable development has been also extensively discussed in the academic realm. The literature has evolved towards a dual perspective integrating so-called "climate change lens" and "sustainable development lens" (e.g. Robinson, et al., 2006; Robinson & Herbert, 2005). Thinking about climate change in a sustainable development perspective requires broadening the focus and start examining points of intersection, trying to answer the fundamental question of how to guarantee economic and social development without compromising the environment. Many studies - emphasizing the economic, ecological and human/social dimensions of sustainable development – developed based on economic theory, complex systems approaches, scenario analysis, ecological, and social science. Some looked at the importance of relating mitigation efforts to socio-economic factors, such as technological improvements and behavioral change (i.e. improvements in agricultural yields, changes in dietary habits) affecting future projections for resource use and consumption (e.g. Swart, Robinson, & Cohen, 2003; Robinson & Herbert, 2005). Others focused on the linkages between adaptation and sustainable development pointing out how both aspects play a key role in decreasing vulnerability while simultaneously enhancing community resilience (e.g. OECD, 2006; Smith & Pilifosova, 2001; Wilbanks & Kates, 2010). Several scholars explored these linkages from a developing countries perspective, taking into account local and regional circumstances aiming at identify innovative bottom-up approaches (e.g. Beg N. et al, 2002; Bizikova, Robinson, & Cohen, 2007); while a vast bulk of the literature also focused on decision support tools to help advance pluralistic decision processes and to develop complementary policies linking climate change and sustainable development (e.g. Wilson & McDaniels, 2007). International organizations, research institutes, universities, and public authority bodies (e.g. Organisation for Economic Co-Operation and Development (OECD); United Nations Environment Programme (UNEP); the World Bank; the Asian Development Bank (ADB); the Centre for Climate Change Economics and Policy (CCCEP); Fondazione Eni Enrico Mattei (FEEM); the Food Agricultural Organization (FAO)) have been also increasingly active in enhancing efforts to develop integrated analyses and assessments. The Asian Development Bank (ADB), for example, produced a study stressing how low-carbon growth is a pattern of development that can decouple economic growth from carbon emissions, pollution and resource use, while promoting growth through the creation of new environment friendly products, industries and business models (ADB, 2012). The OECD pointed out to the emerging trend of integrating climate resilience into national development visions coinciding with a general shift in the understanding and practice of both climate change adaptation, mitigation and sustainable development strategies (OECD, 2014). Also a vast array of international and European projects (e.g. Climate Change Mitigation and Poverty Reduction – Trade-Offs or Win-Win Situations? (CliMiP)), as well as networks and knowledge platforms (e.g. Green Growth Knowledge Platform, the Climate and Development Knowledge Network, Climate-Smart Planning Platform) have been established advancing the knowledge-base on integrating climate change and sustainable development.

Accordingly, a span of new methodologies and frameworks has been produced (e.g. Munasinghe, Canziani, Davidson, Metz, Parry, & Harisson, 2003; Robinson & Herbert, 2005). The IPCC reports reflected these changes, with its Third Assessment Report (TAR) addressed equity issues related to global sustainability and alternative development pathways (Swart et al., 2003; Swart and Raes, 2007) and clearly mentioning sustainable development as a crucial aspect to consider in relation to climate change impacts (e.g. Swart et al., 2003; Swart and Raes, 2007). Following, the AR4 included targeted chapters on sustainable development in both WG II and WG III reports, with a focus on both climate-first and development-first literatures (Denton, et al., 2014); and more recently Chapter 20 of the AR5 indicated climate change as a threat to sustainable development, highlighting how the interlinkages between these two fields call for innovative and effective climate resilient pathways (Denton, et al., 2014).

Figure 2.1: Evolution of the conceptual basis in the IPCC reports



Source: adapted from Munasinghe et al., 2003.

The evolution of the IPCC reports reflects not only research advancements, but also a policy evolvement dictated by the necessity of a better understanding of the implications, potential benefits and tradeoffs between these two fields (e.g. Klein, Schipper, Lisa, & Dessai, 2005; Munasinghe, , 2010). Addressing climate without addressing the development deficit could be an ineffective response further fragmenting an already complicated development landscape. Without effective frameworks to build resilience and to reduce vulnerability, climate change will act as a threat multiplier and will generate additional socio-economic problems in both low-income and in middle to high-income countries (e.g. Denton, et al., 2014; OECD, 2014). Although, ill-designed climate change responses may disrupt sustainable development policy and potentially offset already achieved gains, posing critical challenges to governance and political systems (Denton, et al., 2014). A better understanding of how to integrate mitigation, adaptation and sustainable development dimensions became thus an essential part of planning for and pursuing of effective national and international climate and development policies (e.g. Wilbanks & Sathaye, 2007; Bizikova, Robinson, & Cohen, 2007). A new array of concepts emerged: climate-resilient pathways[8], low-carbon resilient development[9], and climate compatible development[10] (e.g. Denton, et al., 2014; Fisher, 2013) aiming at identifying vulnerabilities to climate change impacts, assessing opportunities for reducing risks, and taking actions that are consistent with the goals of sustainable development (Fisher, 2013). The whole of these theoretical frameworks is constructed on the rationale that efficiently combining mitigation, adaptation, and sustainable development objectives into single strategies can promote responses that are economically, environmentally, and socially sustainable. Building upon this rationale, the UNFCCC´s decided to shift from a project-based approach – based on National Adaptation Programmes of Action (NAPAs) - towards promoting national, strategic responses that seek to incorporate joint approaches to mitigation and adaptation in the context of sustainable development (Denton, et al., 2014). This includes Nationally Appropriate Mitigation Actions (NAMAs), and the recent establishment of the National Adaptation Plan (NAP) process that supports developing countries in planning and implementing national-level responses to climate change integrated with development planning processes (Denton, et al., 2014). Others well-known practical examples include the Clean Development Mechanism (CDM); the Joint Implementation (JI), and the Reducing Emissions from Deforestation and Forest Degradation in Developing countries (REDD+)[11] which seek to offset carbon emissions, build adaptive capacities of local communities, and provide sustainable development dividends (e.g. Denton, et al., 2014).

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[8] Climate-resilient pathways are development trajectories that include two course of actions to reduce climate change and its impacts, as well as actions to ensure that effective risk management strategies can be identified, implemented, and sustained as an integrated part of sustainable development processes (Denton, et al., 2014).

[9] Low-carbon pathways refer to strategies aiming at decoupling economic growth from emissions combined into a single agenda. Building upon this concept, low-carbon resilient development (LCRD) supports climate-resilient development, while addressing climate change by reducing carbon emissions, bringing together climate change mitigation and adaptation (Denton, et al., 2014).

[10] Climate compatible development (CCD) builds upon the long-established concepts of mitigation and adaptation combined though with the newer notions of climate resilient development and low-carbon development (Tompkins, et al., 2013).

[11] Agreed upon by Parties to the United Nations Framework Convention on Climate Change (UNFCCC) at its 16th Conference of the Parties (COP16) in Cancun.

3 Climate Smart Agriculture: the evolving discourse

3.1 The food system and climate change

The increasing integration of climate change and sustainable development together with the application of strategies accounting for mitigation, adaptation and development concerns and objectives has been remarkably evident in the agriculture sector. Any effect of climate change on agriculture inevitably feeds back to the climate system (Bosello & Zhang, 2005; Smith, et al., 2007). Naturally, the extent of these impacts largely varies across regions and is strongly dependent on the intensity and timing of the changes but also on their combination, which is more uncertain (IPCC, 2007c). Thus, one of the main challenges is properly anticipating the impacts of climate change on agriculture that are in general expected to further affect the agricultural sector, i.e. increase of mean temperature and weather variability; changes in water availability and in the frequency and intensity of extreme events; sea level rise and salinization; perturbations in ecosystems (e.g. Bosello & Zhang, 2005; IPCC, 2007a). Several studies /models have attempted to anticipate these impacts focusing on the role of temperature, the interaction between soil moisture and changing precipitation patterns (extreme events), between carbon dioxide concentration and crops' productivity, as well as the feedback of agriculture on climate change (Bosello & Zhang, 2005). By 2100, it is anticipated that up to 40% of the world´s land will have to adapt to novel or altered climates (Gonsalves, Campilan, Smith, Bui, & Jimenez, 2015). Tropics and sub-tropics will experience negative conditions, such as falling yields, but an increased variability of production in both crops and livestock productivity in high-latitude regions (e.g. Gonsalves, Campilan, Smith, Bui, & Jimenez, 2015; IPCC, 2014). Modeling studies suggest that climate change could result in global agricultural production falling by 2% per decade through to 2050[12] (IPCC, 2014), the average yield declines could be as severe as 23% for South Asia, 17% for East Asia and the Pacific, 15% for Sub-Saharan Africa, and 14% for Latin America, even when accounting for adaptive behaviors (e.g. changed agricultural practices and crops, more irrigation, and innovation in higher yield crops) (Hallegatte, et al., 2016: 51). Southern African countries risk losing 30% of its coarse grain output by 2030 (Lenton T. et al, 2008). World Bank´s projections for Africa point out to a loss of more than 4% of total arable land by 2039 with Eastern Africa losing up to 15% of its cropland area within

[12] Based on projections of staple grains yields and livestock output. Source: IPCC, 2014.

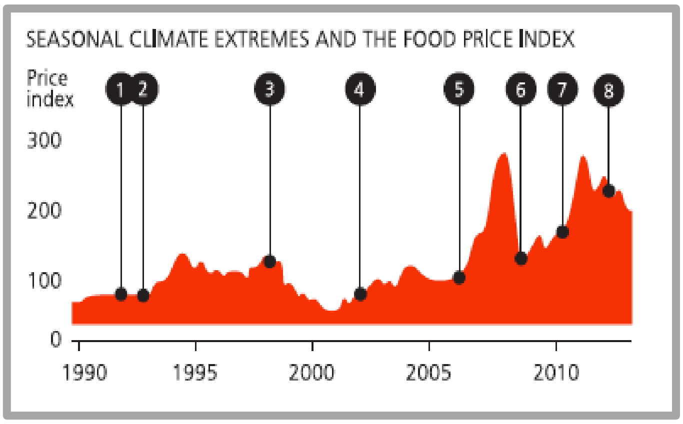
the next 30 years (Lotsch, 2007). Some projections consistently suggest that these negative effects seem to be already happening in some countries, like China and Brazil, where maize yields would have been 7% to 8% higher today had climates been stable (Lobell, Schlenker, & Costa-Roberts, 2011). On the other side, agriculture contributes to total greenhouse gas (GHG) emissions: the agricultural sector remains the main emitter of nitrous oxide (N_2O) coming from fertilizers and manure, and methane (CH_4) coming from livestock and wetland or paddy rice farming (Bosello & Zhang, 2005). The IPCC AR4 Working Group III assessed that agriculture accounted for an estimated emission of 5.1 to 6.1 gigatons of carbon dioxide equivalent ($GtCO_2e$) in 2005: 10-12% of total global anthropogenic GHG, and accounted for about 60% of N_2O and about 50% of CH_4 (Smith, et al., 2007: 499). In the same year CH_4 contributed with 3.3 $GtCO_2e$ and N_2O 2.8 $GtCO_2e$ (Smith, et al., 2007). Globally, agricultural CH_4 and N_2O emissions have increased by nearly 17% from 1990 to 2005 (Smith, et al., 2007:499). An average annual emission increases of about 60 megatons of carbon dioxide equivalent ($MtCO_2e$) per annum (Smith, et al., 2007:499). Agriculture is also a major driver of deforestation, which roughly accounts for an additional 17% of global GHG emissions (IPCC, 2007c). If agricultural emissions are not reduced, they will account for 70% of the total GHG that can be released if temperature increases are to be limited to the 2°C.[13]

Despite the attention paid to climate change impacts on agriculture and vice versa, past researches have placed a lot of emphasis on agricultural production, neglecting the issues of food (in)security, which it is also a major socio-economic burden. This is also reflected in the current agricultural and food systems, which do not provide all people with a healthy, safe, and nutritious diet; many of those who get sufficient calories are still malnourished. Even though we produce enough food, between 2010-2012, there were still almost 870 million undernourished people (FAO, 2012a), and 1 billion malnourished people worldwide. At the same time, more than 1.4 billion adults are overweight and one third of the whole food produced, is waste (UN-DESA, 2015). More recently, however, food security[14] and its elements of accessibility and stability have gained renew attention and are increasingly under scrutiny especially in developing counties (Porter, et al., 2014), as climate change impacts are calling for

[13] Source: https://ccafs.cgiar.org/bigfacts/#theme=food-emissions
[14] Many definitions of food security exist, and have been the subject of much debate. Whereas many earlier definitions centered on food production, more recent definitions highlight access to food, in keeping with the 1996 World Food Summit definition that food security is met when "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (Porter at al., 2014).

new approaches that take into account the complex interactions between social and ecological systems. New modeling simulations showed that mitigation policies that do not consider food security could have impacts larger than those of climate change (Hallegatte, et al., 2016) adding up to the environmental challenges.[15] Climate change could make agricultural areas unsuitable for cultivation of key crops, resulting in large economic impacts for agricultural dependent economies, which could experience problems in terms of food security, through a double negative effect on reduced domestic agricultural production and increased food prices on the global market (Hallegatte, et al., 2016; Porter, et al., 2014). Losses in the agricultural sector will lead to spikes in food prices that will put upward pressure on most vulnerable societal segments (e.g. Hallegatte, et al., 2016; IPCC, 2014; FAO, 2013a). The series of weather shocks in 2015, such as the flooding in southern Africa, drought in Central America, and a major earthquake in Nepal, are an appropriate example of how climate change affects food systems leading to widespread food insecurity (IFPRI, 2016:3).[16]

Figure 3.1: Seasonal climate extremes and the food price index[17]



Source: CGIAR, 2013

[15] For matter of clarity, it should be pointed out that these estimates come with a high level of uncertainty (Porter et al., 2014). They vary depending on the type of climate, crop, and economic model applied, as well as on assumptions about CO_2 fertilization (its presence should mean higher crop yields) - hence the -30% to +45% range in likely food price changes in 2050 (Porter et al. 2014). They do not include local pollution and ozone, pests and crop diseases, food losses along the supply chain, or natural disasters that could result in temporary, but very severe, food price shocks. Thus, estimated of current and future variation in the distribution and vulnerability to loss of food access across household types makes impacts assessment complex and difficult (Porter et al., 2014).

[16] Although prices of food (and fuel) have declined in the latter half of 2008 and early 2009, in 2011 price increased again to those of 2007.

[17] Although, recent food price hikes have been linked to climate extremes, it should be pointed out that other factors also play a role, including market forces, trade regulations (including tariff and import restrictions), and competing demand for resources (e.g., land and water). 1. Australia, wheat; 2. US maize; 3. Russia wheat; 4. US wheat, India soy, Australia wheat; 5. Australia wheat; 6. Argentina maize and soy; 7. Russia wheat; 8. US maize.

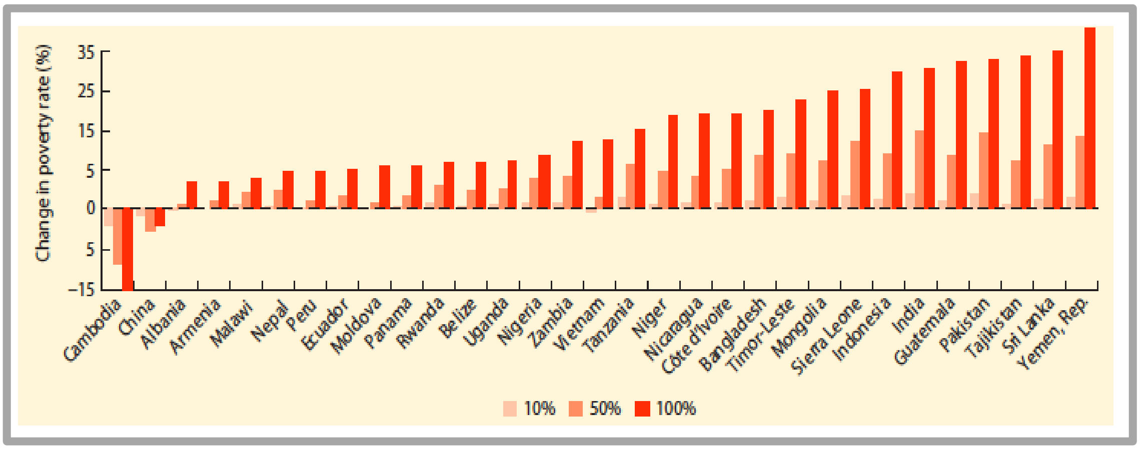
According to OXFAM, who modeled the effects of climate change and extreme weather events on food prices by 2030, the average price of staple foods could more than double in the next 20 years compared with 2010 trend prices – with up to half of the increase caused by climate change (i.e. changing mean temperatures and rainfall patterns) (Hallegatte, et al., 2016). These estimates may be even too optimistic if they do not account for impacts of pests, diseases, interaction with local pollution, and extreme weather events (Hallegatte, et al., 2016). Over the long term, the risks of harmful price impacts could be high, especially without CO_2 fertilization (Hallegatte, et al., 2016). Another simulation carried out by the World Bank suggested that in scenarios with continued high emissions and no CO_2 fertilization, climate change would increase world agricultural prices by 4% to 5.5% in 2030. Over time, these impacts could increase and be as large as 30% by 2080 (Hallegatte, et al., 2016: 53). Sub-Saharan Africa and South Asia regions will be the ones most severely hit with prices' impacts as high as 12% in 2030, and 70% by 2080 in Sub-Saharan Africa in a worst-case scenario (poverty and high emissions without CO_2 fertilization) (Hallegatte, et al., 2016). In the same scenario, prices would rise by 5% by 2030, and 23% by 2080 in South Asia, 4% and 9% in East Asia and the Pacific, and 3% and 12% in Latin America (Hallegatte, et al., 2016). Even when accounting for CO_2 fertilization, in 2080 prices would be 29% higher in Sub-Saharan Africa and 16% in South Asia (Hallegatte, et al., 2016).[18] In a world with slow economic growth (in 2015 the global economic growth was extremely slow, at 2.4% amid slow growth the developing countries (IFPRI, 2016) coupled with high GHG emissions (that is, a scenario in which global temperatures increase by approximately 4°C by 2100), food availability could plateau at levels far below current levels in developed countries (Hallegatte, et al., 2016).

What happens to food prices is particularly critical for poverty levels given their repercussions on poor households' budgets, leading to long-term effects on social development (Hallegatte, et al., 2016). Indeed, repeated climate extreme events impacts could exacerbate the so-called "poverty traps", when households are forced to dispose of productive assets following climate shocks (OECD, 2014; World Bank, 2013a). This combined with the fact that the poorest households spend as much as 60%-80% of their incomes on food would mean, that when prices go up, poorest

[18] Naturally, food prices are not only affected by the biophysical impacts on crop yields, they also evolve depending on the interplay of demand and supply of food, management of losses during storage and transport, and on how countries adapt to climate change impacts (Hallegatte, et al., 2016).

segments of the society would have even less income to spend on other primary needs, such as clothes, shelter, medicines, and schooling (FAO, 2012a). In some African countries, such as Burundi, Chad, the Democratic Republic of Congo, Malawi, and Tanzania, food consumption of the poorest households amounts to over 70% of their total expenditure (Hallegatte, et al., 2016). It was already estimated that the rise in food prices between 2007 and 2008 increased the number of people living in extreme poverty in urban areas in East and South Asia, the Middle East and Sub-Saharan Africa (SSA) by at least 1.5% and the following 2010–2011 price raises episode, increased global poverty by 44 million (Hallegatte, et al., 2016). In 2009, FAO reported that the urban poor face the most severe problems in coping with global recession, as they have even higher food expenditure compared to rural people, giving that the latter have in some cases the advantage to be able to self-produce some of the food they consume (e.g. FAO, 2009; Hallegatte et al., 2016). In the short run, increasing food prices due extreme events could result in an additional 100 million people living in extreme poverty by 2030 (Hallegatte, et al., 2016). Thus, unless measures are taken to reduce risks, Climate change will further increase the vulnerability of local food supply systems and levels of poverty will consequently aggravate and exacerbate inequality for decades to come in context of volatile food prices and economic crises, (e.g. World Bank, 2013a; Carraro & Mazzai, 2015).

Figure 3.2: Food price rises[19]



Source: Ivanic and Martin, 2014.

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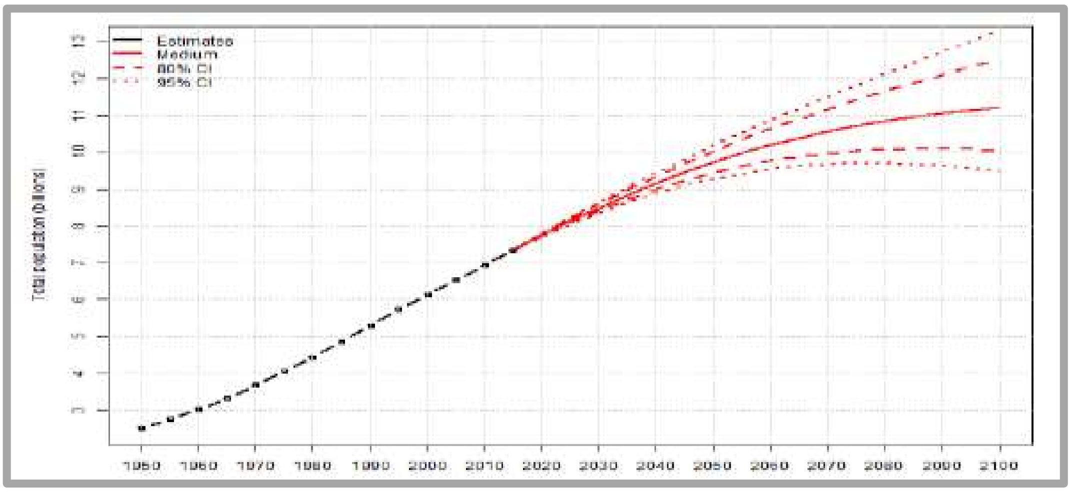
[19] Poverty changes under 10%, 50%, and 100% food price increases. Note: Based on microeconomic simulations specified with the Global Trade Analysis Project (GTAP) general equilibrium model. Simulations measure the short-term impacts on poverty (without any supply or wage adjustments) of a uniform change in all food prices for 10, 50, and 100 percent (without productivity effects). Poverty is defined by the percentage of households living on less than $1.25 per day (Hallegatte et al., 2016).

Furthermore, it is expected that a large segment of the population living across Sub-Saharan Africa and South Asia countries will suffer of decreasing food accessibility (Gonsalves, Campilan, Smith, Bui, & Jimenez, 2015; IPCC, 2015). In low-income countries poorer households in the face of 10% increase in food price levels will face a reduction in daily food intake by 301 kilojoules, equal to 72 kilocalories (Green, et al., 2013). This could lead to under-nutrition, with potentially severe health impacts, especially on children, and elderly people (Hallegatte, et al., 2016). Households directly involved in farming practices might also suffer from decrease accessibility to food due to climatic variations that could reduce both income and direct consumption. In 2013, FAO estimated that 60% of malnourished were actually food producers, smallholders and pastoralists, with 20% living in cities and 20% landless rural people (FAO, 2013a). The net effect of climate change on poverty - resulting from the combination of impacts on productivity, consumption prices, and incomes - is likely to be negative in many countries, and globally it is expected to worsen the situation, putting 49 million additional people at risk of hunger by 2020, and 132 million by 2050 (FAO, 2011a). Thus, certain world regions not only have a larger fraction of people relying on agriculture for their livelihoods, but they may also carry a higher burden of malnourished people (Gonsalves et al., 2015; FAO, 2011a).

Impacts on food systems are also dependent on population growth: undeniably, despite the drastic fall in the growth rate, the absolute annual increments continue to be large, 83 million persons are being added to world population every year (UN-DESA, 2015). Between now and 2050, the actual world's population of 7 billion is most likely to increase, probably reaching 8.5 billion in 2030, 9.7 billion in 2050 and 11.2 billion by 2100 as shown graphically in the figure below (UN-DESA, 2015).

Figure 3.3: Population of the world: estimates, 1950-2015[20]



Source: UN-DESA, 2015.

Furthermore, though it cannot be claimed with absolute certainty – since several factors affect these trends such as fertility, life expectancy, and epidemic - these increases will mainly take place in developing countries.[21] Current figures, for the year 2013, show that the world population reached 7.2 billion with 5.9 billion (or 82.5% of the world's total) living in the less developed regions (UN-DESA, 2015). Out of these, 898 million reside in the 49 least developed countries and account for 12.5% of the world population (UN-DESA, 2013). The African continent in particular has registered a growing pace of 2.55% annually between 2010-2015 (UN-DESA, 2015:3). It is expected that of the additional 2.4 billion people projected to be added to the global population between 2015 and 2050, 1.3 billion will be placed in Africa, more than half of global population growth between now and 2050 (UN-DESA, 2015). Asia is projected to be the second largest contributor adding 0.9 billion people between 2015 and 2050, followed by Northern America, Latin America, the Caribbean and Oceania (UN-DESA, 2015: 3).

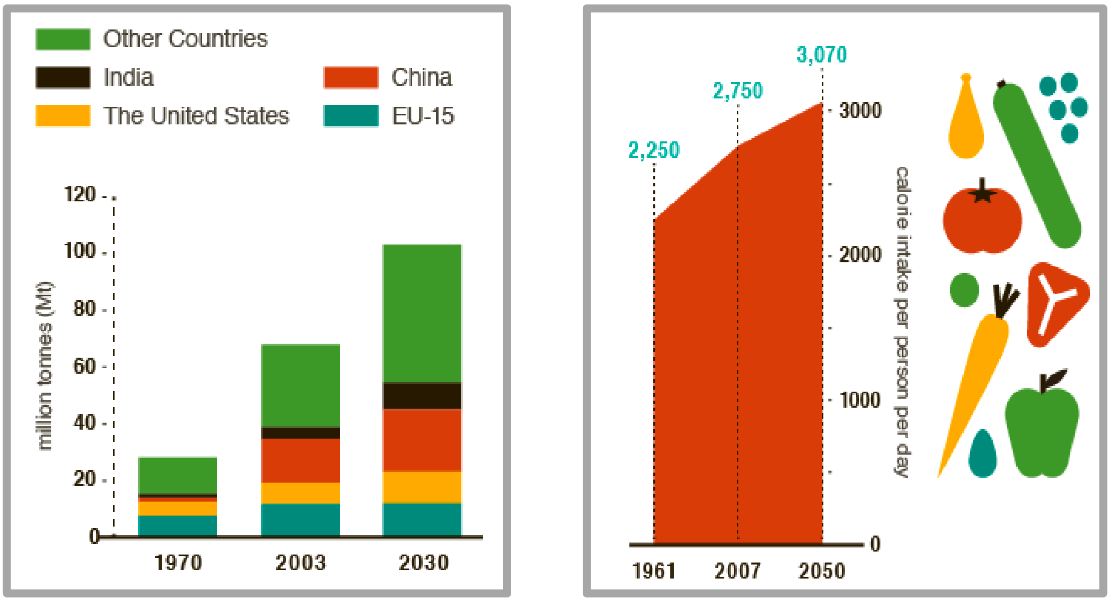
In addition, those countries - expected to have higher population growth rates - are also the ones showing greater changes in food consumption patterns. Globally, food consumption has increased from 2,250 calories per person per day in 1961, to 2,750 calories per person per day in 2007, and this is projected to increase to 3,070 calories per person per day by 2050 (Alexandratos & Bruinsma, 2012: 50). In terms

[20] Medium-variant projection and 80% and 95% confidence intervals, 2015-2100.

[21] When speaking of population projections, it is important to keep in mind that these estimated can vary significantly from one revision to the next. This bears witness to the uncertainties surrounding this variable, and hence the associated food projections (UN-DESA, 2013)

of changing diets, most developed countries have already completed the transition to livestock based diets (FAO, 2013a), while many developing countries are still in this phase (FAO, 2013a). Thus, total global animal protein consumption has more than doubled since 1970 (PBL 2009), and this combined with growing global population rate will lead to an increase in global animal protein demand of 60% by 2030 (Alexandratos & Bruinsma, 2012). By 2050, Latin America's per capita meat consumption (84 kg per person per year) will be on par with that of people in high-income countries (91 kg per person-1 per year) (Alexandratos & Bruinsma, 2012). In South Asia meat consumption will quadruple the amount consumed by 2050 (Alexandratos & Bruinsma, 2012). Accordingly, the production of animal protein will have to be more than tripled if the projected global population of circa 9 billion people in 2050 were to consume meat and dairy products at current North American and European levels.[22]

Figure 3.4: Demand for animal protein and average calorie consumption



Source: CCAFS Big Facts: Food Security[23]

In general, FAO estimated that production would have to increase by 60-70% by 2050 to satisfy the expected demands for food and feed (Alexandratos & Bruinsma, 2012) (FAO, 2013a; World Bank, 2012a). In absolute terms this translates into: cereals production increase by 940 million tons to reach 3 billion tons projected for

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[22] Source: https://ccafs.cgiar.org/bigfacts/#theme=food-emissions
[23] Source: https://ccafs.cgiar.org/bigfacts/#theme=food-security

2050; meat by 196 million tons to reach 455 million tons by 2050; and oil-crops by 133 million tons to reach 282 million tons (oil equivalent) by 2050 (Alexandratos & Bruinsma, 2012). These dietary changes will put additional stress over resources use and distribution, against a backdrop of rising global temperatures and changing patterns of precipitation (Foresight, 2011: 14).

Thus, losses in agricultural productivity due to climate change, population growth, increasing demand of food, and changing dietary habits will generate not only serious competition over land and water resources, but also significantly increase in global emissions. As population moves towards richer and more varied diets, more land and water will be required with water availability projected to become an even more serious problem. Moreover, agriculture currently consumes 70% of total global ″blue water″ (Foresight, 2011). UN estimates reported that producing 1kg rice, requires about 3.500 liters of water, 1kg beef some 15.000 liters, and a cup of coffee about 140 liters (WWAP, 2012). It has been estimated that the demand for water in the agriculture sector could rise by over 30% by 2030 (Foresight, 2011). Simultaneously total global water demand could rise by 35-60% between 2000 and 2025 and this estimate could double by 2050 (Foresight, 2011; WWAP, 2012). At the same time, land dedicated to food production will be under greater competition due to increasing urbanization, desertification, salinization, and sea-level rise, together with global energy demand projected to increase by 45% by 2030: producing food from livestock takes 2.5-10 times, as much energy as producing the same amount of food energy and protein from grain (Foresight, 2011).

3.2 Evolving urban living conditions

Coupled to the population growth and the evolving food production systems and consumption´s patterns, another phenomenon is increasingly under scrutiny, namely the significant enlargement of urban areas worldwide. The current level of urbanization is unprecedented and so it’s the number and size of cities. In 1950, there were only two megacities (cities with at least ten million inhabitants) and five cities with population ranging from five to ten million inhabitants. Today, there are 21 megacities of which 17 in the developing world (UN-DESA, 2013), and the UN-HABITAT has defined the 21st century as the urban century (UN-HABITAT, 2010). In 2008 the world´s urban population outnumbered its rural population (de Zeeuw, H.; Dubbeling , M., 2009) with Sub-Saharan African countries reporting the world´s highest rates of urban growth (de Zeeuw, H.; Dubbeling , M., 2009). According to the United Nations Populations Fund, the world´s urban population is expected to double from 3.3 billion in 2007, to 6.4 billion by 2050 (UN Population Fund, 2007). By 2030, 60% of the world population will be living in cities across Africa and Asia (UN Population Fund, 2007).

This rapid and often-unplanned [24] urban growth increases the vulnerability of population not only in terms of socio-economic risks, but also with respect to exposure to negative environmental impacts (Dubbeling, Caton Campbell, Hoekstra, & van Veenhuizen, 2009; RUAF, 2014). In many cities this rapid urbanization has been accompanied by slum growth [25] negatively affecting prime agricultural land, forests and wetlands, also interfering with the provision of basic services ((UN-HABITAT, 2010; Carraro & Mazzai, 2015; IPCC, 2015), and people in developing countries have been experiencing increasing poverty, food insecurity and malnutrition, as well as the worsening of the environmental and social systems (e.g. (de Zeeuw, H.; Dubbeling , M., 2009; UN-HABITAT, 2010). As result the phenomenon of "urbanization of poverty" or "urban poor" (i.e. underemployed or unemployed citizens, refugees, people dislocated by violence and conflicts and immigrants) has been steadily growing (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011). Studies showed a rate of urban poverty 30% higher compared to rural areas[26] (Ravallion et al., 2007; Baker, 2008).[27] Globally, about 25% to 30% of poor people - measured using a US$1 to US$2 per day standard - live in urban areas (Porter, et al., 2014). In 2002, in developing countries approximately 750 million people in urban areas were living below the poverty line referring to the US$2/day, while 290 million when using the US$1/day line (Baker, 2008). This represents approximately one third of all urban residents ($2/day) or 13% ($1/day), and one quarter of the total poor in those countries (Baker, 2008:3). Looking at the same year, almost half of the world's urban poor were located in South Asia 46%, 34% in Sub-Saharan Africa for US$1/day line (Baker, 2008). Using the US$2/day line, these proportions were

[24] Uncontrolled human activities in urban and peri-urban areas can result in unregulated use of agricultural and natural resource systems and thereby increase environmental degradation of land, water resources and air pollution (Dixit et al., 2014)

[25] The slum population in these countries almost doubled in 15 years (de Zeew and Dubbeling, 2009).

[26] They refer to the time period: 1993, 1996, 1999, and 2002, and analyzing data for approximately 90 low- and middle-income countries. It is also important to highlight that estimates this differs from region to region.

[27] The estimation used two poverty lines, the "$1 a day" and "$2 a day" (which are actually $1.08/day and $2.15/day) (Ravallion et al., 2007; Baker, 2008). The $1/day line is based on the median of the lowest 10 poverty lines in the original compilation of (largely rural) poverty lines used for World Bank (1990). A $2/day line is more typical of poverty lines used in middle-income countries (Baker, 2008).

respectively 40% for Africa and 22% for South Asia (Baker, 2008: 3). In 2008, the UN estimated the total number of urban poor living in developing countries was 1.2 billion (those living on the $1/day line) ((UN, 2008).

Climate change challenges combined with the rapid urbanization´s rate are posing at particular risks many cities. Climate change knock-on effects represent an additional stressor in these rapidly urbanizing world regions, since they are expected to be both regressive and heterogeneous, and, thus, contributing to higher inequality. The attendant increase in natural disasters will strain social relationships and put pressure on existing institutions (Dixit, et al., 2014). City economies might suffer from food shortcomings when agricultural production will decrease in rural areas due to e.g. storms, floods or water scarcity (World Bank, 2013a) and consequently food prices will upturn. In addition, high dependence on food imports, especially for lower income countries with limited foreign exchange reserves, means that any increase in import prices or decline in export earnings could force a decline in food imports, causing their food security to deteriorate even further (OXFAM, 2012). Increasing food prices goes hand-on-hand with growing urban poverty and malnutrition, as food purchasing makes up a large proportion of urban poor households income (World Bank, 2013b). Due to climate change it is expected that rural areas will become less productive and thus will force additional migrations to urban areas (Zeew and Dubbeling, 2009). This will further exacerbate the pressure on urban systems in providing basic services, accelerating the process of slums formation in city marginal areas, and worsening of social and environmental conditions (de Zeeuw, H.; Dubbeling , M., 2009; World Bank, 2013b; UN Population Fund, 2007). As highlighted by UN-Habitat, cities are among the major contributors to climate change, but also suffering the most severe impacts (UN-HABITAT, 2010) with the urban poor particularly vulnerable to the direct effects (e.g. floods, hurricanes) as well as to the indirect impacts of climate change (e.g. decrease in agricultural productivity).

Accordingly, the strong connection between resilience and the sustainability of socio-ecological systems have been progressively under scrutiny. Researchers and policymakers have started questioning whether cities are and will be adequately prepared to adapt to the heightened risks associated with climate changes, and how will the urban poor, who already struggle to access food and basic services, cope against these increasing levels of insecurity. The size of the environmental, social and economic challenges and the evolving needs of cities require innovative ways to stimulate urban security and local economic development calling for a three-pronged approach integrating mitigation, adaptation, and sustainable development objectives (Dubbeling, Caton Campbell, Hoekstra, & van Veenhuizen, 2009; RUAF, 2014).. Moreover, the tremendous and continuous urbanization in developing countries is calling for strategies that enhance the resilience of their citizens, decrease their vulnerability, while contributing to mitigate climate change, preserving the natural resource base and vital ecosystem services through adaption, and advancing local development.

3.3 Multiple demands: the rise of climate smart agriculture

The scale of the challenges posed by climate change coupled with the demographic growth and the rapid urbanization process are calling for urgent actions ((UN-HABITAT, 2011a; Satterthwaite, Huq, Pelling, Reid, & Romero Lankao, 2007). Forced to face increasing degradation of land and water resources, food insecurity, poverty, and climatic variability, there is renewed attention towards agricultural practices that can achieve food security and at the same time responding to climate change impacts (World Bank, 2008). The core challenge is to sustainably improve food production and increase the resilience of farming systems and livelihoods, by transforming production systems through the introduction of more climate-resilient and low-emissions agricultural practices and by adopting a new climate-smart perspective on agriculture (FAO, 2016). Existing farming practices necessitate to move towards food production systems that are more productive, use inputs more efficiently, have less variability and greater stability in their outputs, and are more resilient to risks, shocks and long-term climate variability, and additionally drive the uptake of more sustainable consumption patterns.

Multiple concepts arose in direct response to these multiple demands,, such as climate-resilient pathways, climate compatible development, and climate smart agriculture (CSA). Because of the challenges agricultural practices have to face, CSA has been gaining increasing popularity as a potential unifying concept for policy, institutional arrangements, and funding channels for responding to climate change, food security, and others sustainable development goals. As defined by FAO in 2010, CSA sustainably increases productivity (i.e. the reduction of emissions for each calorie or kilogram of food produced), enhances resilience and hence adaptation (i.e.

sustainably improved food supplies, and accessibility to it and so reduce poverty), reduces/removes GHG hence promoting mitigation (i.e. the avoidance of deforestation due to agricultural practices; and the management of soils and trees in a way that maximize their carbon sink potential) where possible, and promotes food security and development goals ((FAO, 2011a; Lipper et al, 2014). It, therefore, has a quite broad definition and draws together sustainable productivity, resilience (adaptation), emissions reductions, food security, and development goals under one umbrella (FAO, 2011a).

CSA can enable the identification and reduction of trade-offs and promote synergies by taking into consideration the diversity of social, economic, and environmental factors. It represents an approach that can bring together agricultural practices, policies, institutions and financing in the context of climate change (FAO, 2013a) and that can enable the re-orientation of agricultural development under the new realities of climate change (Lipper et al, 2014). It supports, for example, sustainable intensification on already cultivated land generating a major mitigation effect. Studies show that, at the global level, from 1961 to 2005, crop production increased by over 160%, mostly as a result of 135% yield increases, with only 27% increases in crop area (Burney, Davis, & Lobell, 2010). CSA also supports the decreased use of fertilizers, whose production is an important source of CO_2 (FAO, 2013a). Nutrients are essential to increase yields, but production of synthetic fertilizers is energy intensive, with high CO_2 emissions and economic costs and when applied in the field, these fertilizers contribute to N_2O emissions (FAO, 2013a). When correctly implemented, CSA can contribute to find a balance between competing objectives and intertwined goals realizing solutions that increase productivity, enhance resilience and mitigate the negative effect of climate change, while contributing to address sustainable development concerns in a forward-looking perspective (FAO, 2013a; FAO, 2013a).

3.4 Urban and Peri-urban Agriculture: as a climate-smart strategy

Agriculture is increasingly required to be resilient coping with and recovering from shocks and stresses, to reduce greenhouse gas emissions, to protect and restore ecosystem services (e.g. water, biodiversity, soil); to diversify away from fossil fuel based growth; and to promote rural employment. These challenges are putting increasing pressure on natural and social resources especially in and within urban areas. The recent food and economic crisis brought to light of the need to give more attention to the rising vulnerability of urban systems to climatic shocks, also thanks to the realization that the problem of hunger has more to do with inequalities in distribution and that increased food production was only part of the solution. The concept of food security has shifted from simply being a question of availability of food to the more complex issue of access at the household or individual level (Lwasa, Mugagga, Wahab, Simon, Connors, & Griffith, 2014). It is the dominance of the cash economy over access to such a basic need as food that links urban food systems to poverty and vulnerability to food insecurity (Lwasa, Mugagga, Wahab, Simon, Connors, & Griffith, 2014). Urban and peri-urban agriculture (UPA) has thus increasingly regained international attention as a viable intervention strategy to help the urban poor to earn extra income, and to reduce their reliance on cash income for food, as well as increase their access to food (Dubbeling & de Zeeuw, 2011; Lwasa, Mugagga, Wahab, Simon, Connors, & Griffith, 2014; UN-HABITAT, 2011a).

UPA is not a ne concept, already in 1999, the FAO Committee on Agriculture (COAG) brought the attention of the international community to the growing food requirements of urban areas and mandated the FAO to consider UPA an integral part of agricultural production systems, with emphasis on its role in feeding the cities creating employment and generating income for the urban poor (FAO, 2011b). Subsequently at the World Food Summit in 2002, UPA practices were officially recognized as a key element in food security strategies. In 2007, the World Meteorological Organization (WMO) suggested more urban and indoor farming as a response to the ongoing climate change challenges and a way to build more resilient cities.[28] Similarly, the UN High Level Task Force on the Global Food Crisis identified UPA as a key strategy to alleviate urban food insecurity and build more resilient cities (Stewart, Korth, Langer, Rafferty , Rebelo Da Silva, & van Rooyen, 2013). In 2008 a joint World Bank (WB)/FAO paper reported: "… t*he World Bank and FAO, … will promote - urban poverty alleviation - related programs and projects in the context of the MDGs and more specifically MDG1 ' Eradicate extreme poverty and hunger' and MDG7 'Ensure environmental sustainability…*" (World Bank & FAO, 2008: 5). The International Development Research Centre (IDRI) reinforced this commitment with its *"Cities Feeding People"* program initiative[29] and *"Agropolis"* program.[30] The

[28] UN Agency calls for urban agriculture: WMO press release December 7, 2007.
[29] The program initiative was launched in 1997, it looked at ways to: reduce transaction costs associated with processing individual grant requests; compare and assess more systematically such

international agriculture research organizations (CGIAR) started the *"Urban Harvest"* programs[31], and the FAO included urban and peri-urban agriculture in its agenda creating the *"Food for the Cities"* priority action[32] that forms part of a wider network of organizations, consisting of the UNDP/UN-Habitat *"Sustainable Cities Program"*; the IDRC' s *"Urban Poverty and Environment Program";* and the Resource Centre on Urban Agriculture and Food Security (RUAF). All supporting UPA centered activities aiming to address food insecurity and resilience in urban contexts (Stewart, Korth, Langer, Rafferty , Rebelo Da Silva, & van Rooyen, 2013).

Many definitions of UPA have been coined over the past decades. This is because though, usually addressed as single strategy urban and peri-urban agricultural practices differentiate in terms of being purely subsistence-oriented or recreational at the micro scale, small-scale semi-commercial gardeners and livestock keepers, to medium- and large-scale fully commercial enterprises (de Zeeuw et al., 2011), being practice as part-time activities or be the principal subsistence activity, as shown by Table 3.1.

Table 3.1: Main key characteristics of urban and peri-urban agriculture

Urban agriculture	Peri-urban agriculture
UA is a part-time job	PUA is a full-time job
Smaller areas cultivated, more subsistence production	Larger cultivated areas primarily for market oriented production
Lower availability of natural resources	Higher availability of land and others natural resources
Higher costs so practice by poor urban dwellers for subsistence	Lower cost of labor and land so practices by groups and individuals with ready access to capital markets

Source: Adapted from FAO, 2001

applications; network young researchers among themselves; and generally articulate synergies between training and other related and concomitant CFP activities (institutional research, information dissemination, result utilization and evaluation).

30 AGROPOLIS constitutes IDRC's own contribution to the research training component of the Global Initiative of the Support Group on Urban Agriculture (SGUA) formalized in Ottawa in 1996.

31 The Initiative was launched to focus the efforts and collective knowledge of the 15 International Agricultural Research Centers, which CGIAR supports on issues relevant to urban and peri-urban agriculture. Hosted by the International Potato Center, the Initiative established a global Coordination Office in Lima, Peru, in 2000 and regional coordination capacity in Asia, in Africa and in Latin America.

32 In 2001, FAO launched this multidisciplinary initiative "Food for the Cities" which aims at addressing the challenges that urbanization brings to the urban *and* rural population, as well as the environment, by building more sustainable and resilient food systems.

To cite some examples, (Foeken & Mwangi, 2000) stressed the difficulties in making a spatial distinction between 'urban' and 'peri-urban' areas, resulting in the use of the terms "urban agriculture" and "peri-urban agriculture" synonymously (World Bank, 2013b). In 2000, (Mougeout, 2000) developed one of the most widely used definitions of UPA understood as any agricultural activity occurring in built-up 'intra-urban' areas and the 'peri-urban' fringes of cities and towns. (Obosu-Mensah, 2002) defined urban agriculture as the practice of farming within the boundaries of towns/cities. Other scholars concentrated more on the 'peri-urban' concept, generally understood as the physical interface (Mwalukasa, 2000; van Veenhuizen, 2006), while others looked more in-depth into the complex rural–urban interlinkages Lynch, , 2005; Allen, 2010). The FAO describes *'urban agriculture'* as agriculture that takes place within the built-up city and *'peri-urban agriculture'* as agricultural practices occurring in the areas surrounding the cities (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011). UPA thus comprises of agriculture activities – within cities of their surroundings - that grow or raise, processes and distribute a diversity of food and non-food products, use/re-use largely human and material resources, products and services, and in turn supply human and material resources, products and services largely to that urban area (Mougeout, 2000). Simply put, UPA can be practiced in a variety of places (i.e. on field plots, on vacant public land, in gardens, on rooftops, in barns and cellars), and most often it focuses on perishable and high-value products i.e. green vegetables, fresh milk, eggs, poultry, pig meat, and fish that can be grown in confined spaces (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011).

Academically, in 1996, the publication of the book *Urban Agriculture, Food, Jobs and Sustainable Cities* by the UN Development Programme provided an overview of early research UPA and marked the start of more intensive researches (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011). This early literature strongly focused on UPA´s contribution and impacts on food production, improvement of nutrition, its health risks, its possible contribution in waste recycling and its contribution to urban employment and reduction of inequalities (Dubbeling & de Zeeuw, 2011). As a consequence, for a really long time, urban and peri-urban farming practices have been considered, at best as a survival option for the urban poor in times of crisis (Mkwambisi, Fraser, & Dougill, 2011), and in the worst cases sources of problems rather than a possible solution, due to their possible health and environmental risks, (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011; Dubbeling & de Zeeuw, 2011). Thus, policy-makers especially in low and middle-income countries emanated restrictive (or at best partially permissive) policies, discouraging UPA´s integration into urban planning processes, with little or no attention paid, to its benefits (World Bank, 2013b; Mwalukasa, 2000; de Zeeuw, Van Veenhuizen , & Dubbeling, 2011). Currently, legitimate frameworks for managing and regulating UPA are in many low and middle-income countries either non-existent or institutionally complex and these farming practices are often illegally practiced (World Bank, 2013a). This is also reflected in the common denominator of various articles and studies underlining urban policy-makers reluctance to engage in pro-urban agriculture policies.

This increasing attention translated into a widening of the initial body of research. New analyses emerged providing critical insights and sketching a clearer picture of how UPA practices can strongly contribute to the resilience and subsistence of many urban households and food production systems[33], in the context of rapidly growing cities (De Bon, Wardekker, & van der Sluijs, 2010). A new array of UPA´s analyses emerged, investigating the sustainability and dynamics of this type of land use through the development and/or revision of tailored frameworks, such as the FAO´s Framework for Evaluating Sustainable Land Management (FESLM) (Drechsel & Dongus, 2010). More and more analyses documented the characteristics, challenges and benefits (i.e. food security, increase household income and dietary diversity of the poor) of UPA in cities in low and middle-income countries (Drechsel & Dongus, 2010; Stewart, Korth, Langer, Rafferty , Rebelo Da Silva, & van Rooyen, 2013; Dubbeling & de Zeeuw, 2011). It has been estimated that 15%-20% of the world´s food is produced in urban areas (RUAF, 2014) and many cities worldwide meet a substantial part of the urban demand of fresh vegetables and fruits through UPA (RUAF, 2014). Poor urban households can supply 20% to 60% of their total food consumption (World Bank, 2013b). Locally produced food generally presents reduced costs, as a consequence of the price differential between producer and final consumer which is lowered to 1:2 or 1:3 in urban agriculture (Moustier & Danso, 2006). UPA practices could therefore also decrease the dependency on imported foods making cities less vulnerable to unexpected economic crises, provide additional income and create functioning safety nets (RUAF, 2014). UPA can also contribute to generate additional employment and income´s diversification opportunities, acting as a safety net in times of crises (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011;

[33] For instance, it has been estimated that circa 22.800-hectare of farmland - within the bounds of Mexico City - produce annually around 15.000 tons of vegetables (FAO, 2014). On the outskirts of Lima, short-cycle vegetables are grown on some 5.000-hectare of irrigated land for sale in the city’s markets (FAO, 2014).

Zezza & Tasciotti, 2008). Already back in the 90s the UNDP estimated that 800 million people worldwide were involved in urban and peri-urban agriculture, of which 200 million were full-time engaged in these kinds of activities (UN-HABITAT, 2010; World Bank, 2013b). By promoting local food production UPA not only could help in reducing the ecological footprint of the city, but also the so-called "foodprint" (RUAF, 2014). Current food systems in many developed countries use over four times more energy in the process of getting food from the farm to the plate than is used in the farming practice itself and many cities in developing countries are quickly moving in the same direction (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011).

More recently, besides its evident food security and diversification, and income generation attributes, studies have started analysing UPA as possible strategy in the provision and maintenance of ecosystem services along the urban-rural gradient (Lwasa, Mugagga, Wahab, Simon, Connors, & Griffith, 2014; Mougeout, 2000; van Veenhuizen, 2006; Dubbeling & de Zeeuw, 2011). UPA practices have started to be increasingly seen an important component of urban socio-economic, ecological systems, possible disaster risks management and development strategy mitigating the adverse effects of climate change as well as the negative environmental footprint of cities (RUAF, 2014; World Bank, 2013b; Dubbeling, Caton Campbell, Hoekstra, & van Veenhuizen, 2009; de Zeeuw, Van Veenhuizen , & Dubbeling, 2011). UPA could decrease communities` vulnerability (e.g. preventing construction on risk-prone land; reducing rapid storm-water runoff; and replenishing ground water); maintain green open spaces and vegetation cover (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011), so improving the urban microclimate and biodiversity (Dubbeling, Caton Campbell, Hoekstra, & van Veenhuizen, 2009; World Bank, 2013b; de Zeeuw, Van Veenhuizen , & Dubbeling, 2011); lower GHG emissions by for instance enhancing the amount of locally produced food, involving less transport, storage, processing, and packaging; and promoting synergistic and cyclical processes between urban domestic and industrial sectors enabling the use in greenhouses of excess heat, cooling water or CO_2 from industry, or the effective use of urban wastewater and organic wastes as compost/fertilizer (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011; Dubbeling, Caton Campbell, Hoekstra, & van Veenhuizen, 2009). The use of recycled or re-used wastewater also help to decrease the demand for fresh water supplies and the discharge of wastewater into rivers, canals and other surface water sources, diminishing pollution (Buechler, Mekala, & Keraita, 2006). Diverting solid organic waste from landfills by composting is also one of the simplest ways to prevent emissions of methane and to reduce the pollution of groundwater due to leachates from the landfill (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011). Reuse of wastewater and composting of organic wastes can also help in reducing the mining of finite mineral resources and energy expended to produce artificial fertilizer, as well as lessens the costs of public waste management (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011). Organic wastes can be employed to generate energy, either by incineration in an electricity producing plant, by capturing methane from composting sites for biogas or by making briquettes for household use (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011).

4 Applied research methods

4.1 A Qualitative Content Analysis & the Case Study Research Method

The recognition of UPA´s potential to act as a climate-smart agricultural strategy has been steadily growing, broadening the body of existing data and studies documenting and array of different definitions, frameworks and criteria used to analyze these farming practices (e.g. de Bon, Parrot, & Moustier, 2010; Zezza & Tasciotti, 2008; Buechler, Mekala, & Keraita, 2006). From the review studies, it is evident that theoretically a lot of emphasis has been placed towards the potential of UPA´s to act as climate-smart agricultural strategy, while simultaneously it also appears that at the implementation level exiting knowledge and data that do not lend for quantitative macro-scale assessments of UPA´s triple-wins impacts in urban contexts. A in-depth understanding of the different constraints and opportunities of UPA, and how it can effectively contribute to making urban realities more resilient and sustainable seems to be still missing. This research aims to contribute to fill this knowledge gap moving from the theoretical assumptions to more concrete evaluations in order to better assess UPA´s effectiveness on the ground as climate-smart strategy and also to better comprehend the influence of context-based economic, environmental and social determinants. To these aims, an innovative multi-method approach has been applied, firstly to review existing data and knowledge, and secondly to enable the analytical comparison of UPA´s practices in cities located in different low and middle-income countries aiming at deriving – to the extend possible – a concrete assessment of UPA´s triple-wins impacts on the ground.

Since secondary source data constitutes the bulk of this study, the first analytical step consisted of the conduction of a qualitative content analysis to gather an overview of existing UPA data and studies framed within a climate-smart agriculture perspective. Content analysis is a research methodology which examines textual data for patterns and structures, singles out the key features to which one wants to pay attention, develops categories, and aggregates them into perceptible constructs (Trochim & Donnelly, 2001). In other words, content analysis allows a qualitative analysis, focusing on quantitative aspects of the research data that are most relevant to the research question(s) (Schreier, 2012). The purpose of the analysis may be of a descriptive or exploratory nature based on inductive[34] or deductive reasoning[35] (Bengtsson, 2016) the latter has been also applied to this study. A pragmatic definition of UPA was also adopted, which well reflects any typologies of UPA (only UPA practices undertaken as leisure activities did not qualify for inclusion in the research) namely "*… urban and peri-urban agriculture is located within ('intra-urban') or on the fringe ('peri-urban') of a town, a city, or a metropolis, that grows and raises, processes and distributes a diversity of agricultural products from both plants and animals, using human, land and water resources, products, and services found in and around that urban area. UPA can be practiced in gardens; rooftops; empty public land; cellars or field plots by urban residents from various backgrounds. The orientation and scale of such activities may vary from subsistence-oriented cultivation, to more recreational types of agriculture at the micro scale, through small-scale semi-commercial gardeners and livestock keepers, to medium and large-scale commercial enterprises…* (World Bank, 2013b: 3).

The qualitative content analysis involved an extensive review of literature, including grey literature, journals articles, projects' reports, international conference proceedings, books, and official policy documents. The initial step for gathering the necessary documents was conducted on the basis of a Boolean search logic, applying a specific range of search terms/criteria: urban agriculture "AND" climate change mitigation; urban agriculture "AND" climate change adaptation; climate-smart "AND" urban agriculture; urban agriculture "OR" peri-urban agriculture "AND" climate change; urban agriculture "OR" peri-urban agriculture "AND" sustainable development; urban and peri-urban agriculture "AND" food security; urban agriculture "AND" resilience. Academic reference databases, internet-based search engines, and websites were used and the search terms were adapted as necessary:

- AGRIS: http://agris.fao.org
- CCKN: https://cdkn.org/resources/?loclang=en_gb
- CGIAR: http://www.cgiar.org/resources/
- FAO: http://www.fao.org/urban-agriculture/en/
- IDRC: http://www.idrc.ca/EN/Resources/ResearchDBs/Pages/default.asp

[34] Inductive reasoning is the process of developing conclusions from collected data by weaving together new information into theories (Bengtsson, 2016).
[35] While deductive reasoning implies the opposite, the researchers look for pre-existing data by testing hypotheses or principle (Bengtsson, 2016).

- IWMI: http://www.iwmi.cgiar.org/publications/library-catalog/
- Research4 DFID: http://www.research4development.info/
- Resource Centres on Urban Agriculture & Food Security RUAF: http://www.ruaf.org/ruaf_bieb/appflow/bieb_search.asp
- Science Direct: http://www.sciencedirect.com/

Searches were conducted in mainly English, when sources in different languages were found: firstly a translation of the introductory text and/or abstracts was performed through Google Translator and if retained relevant they were included. However, this was limited to Spanish and French documents.

Following as this research also aims at conducting a comparative assessment of on the ground UPA´s triple-wins impacts, the second analytical step consisted of the combination of the qualitative content analysis method with a case study research design. The case study research design enables to narrow down a very broad field into one easily researchable topic, allowing hypotheses testing on particular real-life context situations. It represents a type of qualitative research preferred when "how" or "why" questions have to be answered, and when the focus is on a contemporary phenomenon (Yin, 2008: 2, 5-10). In this research, the specific case study research orientation applied is documentary analysis. This kind of analysis is particularly useful when either the history of events or experiences or situations cannot be investigated by direct observation or questioning (Yin, 2008). It involves the study of existing documents, either to understand their substantive content or to identify paths. Case study research design can be exploratory[36], explanatory[37], or descriptive[38] according to (Yin, 2008). In addition, the selected case studies can be classified as intrinsic[39], instrumental[40], or collective[41] (Stake, 1995). In this research taking into account the importance of producing findings that would be well reflective of the current status quo of UPA practices in low and middle-income countries, a descriptive research design was followed and collective case studies gathered, through a purposive

[36] Exploratory seeks to define research questions of a subsequent study or to determine the feasibility of research procedures (Yin, 2003);
[37] Explanatory designs seek to establish cause-and-effect relationships (Yin, 2003);
[38] Descriptive design attempts to present a complete description of a phenomenon within its context (Yin, 2003).
[39] Intrinsic case studies focus on a particular individual, event, situation, program, or activity (Stake, 1995).
[40] Instrumental cases are used to better understand a theory or problem (Stake, 1995).
[41] A collective case study aims to understand a theory or problem by combining information from smaller cases (Hartely, 2004).

sampling strategy involving the selection of a small number of important cases to "yield the most information and have the greatest impact on the development of knowledge" (Patton, 2015: 276). The combination of the qualitative content analysis and the case study research design resulted in the collection and revision of a total of 130 documents. These studies span various disciplines in order to best assess the linkages between the social and ecological dimensions of UPA, and cover different world regions. From a temporal perspective efforts have been devoted to the inclusion of most recent data and analyses. Nevertheless, building the research on secondary sources data, it was also necessary to lean strongly on the available documentation, so the time-span of the reviewed documents is rather ample ranging from 1994 to 2016.

Following, in order to determine which case study to analyze in the third analytical step of this research a so-called "coding" approach, which exemplifies in the aggregation of key data into a small number of themes/categories, was applied. This process is particularly adequate when dealing with large amount of textual information, as in this research, to determine key information, identify their frequency, theoretical paths and relationships (Plumins, Sceulovs, & Gaile-Sarkane, 2016). In the past this was done manually by the researcher(s), nowadays, however, more and more qualitative data analysis software packages are being developed, reducing the time needed and possible human errors.[42] In this study, the data coding have been performed through a qualitative computer analytical program, the *MAXQDA Analytics Pro 12.*[43] Its application enables the development of datasets building upon a triple-wins rationale, including sustainable development, climate change adaptation and mitigation criteria, which have been used to determine which cities to include through the computation of frequency hits and variance, as shown in the Appendix I reporting the three crosstabs representative of the reviewed countries. The cities displaying higher frequency hits as well as greater variance with

[42] It should be mentioned that numerous scholars have discussed the advantages and limitations of using qualitative data analysis software packages in academic research. On the one hand, proponents hailed them for faster and more efficient data management (Rodik and Primorac, 2015). On the other hand, others scholars lamented the high financial cost and the considerable time and effort required to learn how to use them as well as the fact that they might induce the researcher to put too much trust in the tools thereby potentially generating unrealistic expectations from the research (Rodik and Primorac, 2015).

[43] MAXQDA was first released in 1989. It is available online: http://www.maxqda.com (accessed on November 2016). The MAXQDA supports the process based on case-oriented analysis by classifying and if necessary quantifying the qualitative data or parts of it into quantitative estimates. The software works, amongst others, with word documents, PDFs, images, audio and video files. It can be used to generate basic charts to compare frequency and percentages for variables or codes. It can calculate descriptive statistics, including mean, standard deviation, variance, quartiles, median and range.

respect to the triple-wins criteria have been included in the study. This process resulted in the selection of nine cities: namely Accra (Ghana); Nairobi (Kenya); Kampala (Uganda); Rosario (Argentina); Lima (Peru); Havana (Cuba); Kesbewa (Sri Lanka); Kathmandu (Nepal); Hanoi (Vietnam).

With respect to the qualitative content and case study analyses and the relative coding process, it is also important to highlight the selection rationale and different challenges, regarding data availability and comparability faced. The unit of analysis comprises of UPA practices implemented at the cities level in low and middle-income countries, thus excluding documentation on North America, Western, Eastern and Northern Europe, Australia and New Zealand, as well as the Small Island States due their peculiar geographical characteristics. Due to data paucity, the number of reviewed documents for each country varies as well as the criteria in each category. However, the differences in the number of documents have been considered and only relative frequencies taken into account in the conduction of the MDCA PROMETHE II introduced in the next section (as shown in Appendix II). Furthermore, the selected criteria cover all tripe-wins services that are necessary for the evaluation of climate-smart agricultural strategies and from the available secondary data sources are those that can give sufficient estimation of the benefits/impacts that UPA practices generate on the ground. The applied "coding process" conducted through the *MAXQDA* has enabled to overcome the comparability challenge, due to the existing differences in metrics and analytical methodologies applied in the reviewed documents, consisting of a mixture of targeted case study analyses and more broad analytical reviews.

4.2 MCDA: the PROMETHEE II modelling framework

The third analytical step of this research consists of the empirical analysis of the nine case studies performed through a multi-criteria decision analysis (MCDA) method. Due to their analytical peculiarities MCDA are well-suited evaluation methods to compare objects/course of actions with multiple characteristics involving various actors and an high-level of uncertainty (Solomon & Hughey, 2007). They combine information about the performance of the alternatives with respect to the criteria with subjective judgments about the relative importance of the evaluation criteria in the particular decision-making context. There are numerous approaches that fall under the umbrella of the MCDA family. **MAUT** or **MAVT** is the most widely applied method (Belton & Stewart, 2002). It employs numerical scores to communicate the merit of one option in comparison to the others on a single scale by transforming the diverse criteria (i.e. cost, risks, and stakeholder acceptance) into one common dimensionless scale of utility/value (Kiker, Bridges, Varghese, Seager, & Linkovjj, 2005). Developed in the 80s, the **AHP** has in its implementation many similarities with the MAVT/MAUT approach, as it also implies an optimization process (Belton & Stewart, 2002). In the AHP all criteria must be paired against all others and the results are then compiled in a matrix form, employing a numerical scale to compare the choices (Kiker, Bridges, Varghese, Seager, & Linkovjj, 2005). Finally, there are the **outranking approaches**; the two most commonly used are the PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) and the ELECTRE (Elimination and Choice Expressing Reality). Outranking methods are not based on the principle that one alternative is the best-preferred option over the others, but rather they provide a ranking scale assessing the relative and overall performance of each action/object against all criteria (Kiker, Bridges, Varghese, Seager, & Linkovjj, 2005).

These research methods have steadily grown in the literature since the early 1990s as well as their application within the environmental and climate change fields (Huang, Keisler, & Linkov, 2011). They have been progressively used for problem solving, primarily within the area of natural resource management, including the selection of sites for networks of nature reserves; the integration of biodiversity conservation in management plans; wildlife management; environmental conflict mitigation sustainable energy planning; groundwater contamination; and water resources management (Huang, Keisler, & Linkov, 2011). MCDA have been also broadly applied to assess and optimize the selection of mitigation policy instruments including carbon capture and storage measures; sustainable energy options; remediation of contaminated sites; optimization of water and coastal resources; integration of biodiversity conservation in management plans; and urban planning in general (Huang, Keisler, & Linkov, 2011). Table 4.1 provides a snapshot of the distribution of the different MCDA by field of applications:

Table 4.1: Distribution of MCA by methods and applications

		AHP	*MAUT/MAVT*	*PROMETHEE*	*ELECTRE*
Environmental protection	Waste management	15	5	4	0
	Water quality	4	7	1	2
	Air quality/emissions	0	1	6	0
	Energy	14	3	4	3
	Natural resources	7	1	0	0
Intervention type	Stakeholders	16	5	1	2
	Strategy	22	12	6	3
	Sust. Manufacturing	18	2	0	1
	Remediation/Restora tion	4	5	1	2
Complementar y tools	Spatial/GIS	24	5	0	0
	Env. Imp. Assessment	26	5	2	1
TOTAL		**150**	**51**	**25**	**14**

Source: adapted from Huang et al., 2011

Because they can structure an assessment of a complex problem along both cognitive and normative dimensions, more recently, MCDA have been used to provide practical help and guidance for formulating climate-policy as they enable the inclusion of the different monetary and non-monetary dimensions of climate policies, such as aspects that cannot be easily measured in monetary terms, and they also facilitate stakeholders' engagement in the policy-planning process (UNEP, 2011). An example is the *MCA4Climate Initiative* developed by the United Nations Environment Program (UNEP), which aims to support the assessment of how investment in low-carbon and climate resilient technologies could lead to job creation, growth, improved health prospects and other sustainable development benefits (UNEP, 2011).

The MCDA approach used in the present study is based on the outranking method PROMETHEE II.[44]. Outranking methods are well suited to problems in which there

[44] There are different versions of this method: the PROMETHEE I for partial ranking of alternatives and the PROMETHEE II for complete ranking of the alternatives, developed in 1982[44] (Brans & Vincke, 1986). To tackle more complicated decision-making situations, the PROMETHEE III for ranking based on interval; the PROMETHEE IV for complete or partial ranking of the alternatives, when the set of viable solutions is continuous; the PROMETHEE V for problems with segmentation constraints; the PROMETHEE VI for the human brain representation; the PROMETHEE GDSS for group decision-making and the visual interactive module GAIA (Geometrical Analysis for Interactive Aid) for graphical

are a finite number of actions to be assessed on the basis of a range of conflicting criteria and where these criteria metrics are not easily aggregated, measurement scales vary over wide ranges, and units are incommensurate or incomparable (Kiker, Bridges, Varghese, Seager, & Linkovjj, 2005). Therefore, they are particularly suitable for case study analysis building upon a climate-smart agriculture triple-wins rationale. PROMETHEE methods have been extensively used in the energy planning field, for example for the analysis of energy alternatives of applications to geothermal site and small hydro site selection; to assess old vehicle elimination; to rank scenarios for the coating of PVC parts for automobile production; and to build product designs (Kiker, Bridges, Varghese, Seager, & Linkovjj, 2005). Despite their wide application, it is interesting to notice that their up taken in the climate-smart agricultural field can be considered almost non-existent, apart when considering few exceptions, where MCDA have been used to assess the suitability of specific agricultural practices in relation to the available land and often in combination with GIS platforms (Kiker, Bridges, Varghese, Seager, & Linkovjj, 2005). In the next sections the various phases for the application of the PROMETHEE II method are described.

The multicriteria problem

The outcome of any decision making model depends on the information at disposal and the type information may vary according to the context in which one is operating (Cavallaro, 2005). For the implementation of the PROMETHEE II, the procedure proposed by (Brans & Vincke, 1986) is recommended. The PROMETHEE II starts by considering the multicriteria problem:

$$Max\ \{f_1(a), \ldots f_k(a), | \ a \in K)$$

Where K is a finite set of actions a, and f_i, $i=1, \ldots k$ are k criteria to be maximized. The PROMETHEE methods include two phases (Roy, 1991):

1) The construction of an outranking relation on K;

2) The exploitation of this relation in order to provide an answer to (1).

In the first phase, a valued outranking relation based on a generalization of the notion of criterion is considered: a preference index representing the preferences of

representation (Brans & Mareschal, 1994). In 2004, Figueira et al. proposed two additional extended PROMETHEE´s techniques, defined as PROMETHEE TRI for dealing with sorting problems, and the PROMETHEE CLUSTER for nominal classification (Figueira, de Smet, & Brans, 2004).

the decision maker is defined. The exploitation of the outranking relation is realized by considering a positive and a negative flow for each action. A partial preorder (PROMETHEE I) or a complete preorder (PROMETHEE II) on the set of possible actions can be proposed to the decision maker in order to achieve the decision problem.

Identification of alternatives and criteria´s selection

The procedure for the identification of alternatives followed by the selection of criteria is carried out by choosing between different elements to be examined and assessed them using the set of criteria. These elements are called actions or alternatives and need to be identified. In the present study, we use an extended notion of alternative where the objects to be compared are not actions, but rather different case studies. Specifically, in this exercise, the "alternatives" to be examined and evaluated (ranked) are the nine UPA case studies, extensively described in the next section.

The criteria represent the tools that enable alternatives to be compared from a specific point of view. The alternatives are compared pairwise under each criterion. Two alternatives a _and b, can express an outright preference, a weak preference or indifference. In the present study, criteria are represented by a set of mitigation, adaptation and sustainable development indicators, which are presented in the next section.

Evaluation Matrix

Once the set of criteria and the alternatives have been selected, then the payoff matrix is built. This matrix tabulates, for each criterion - alternative pair, the quantitative and qualitative measures of the effect produced by that alternative with respect to that criterion.

Determining the multicriteria preference index

The preference structure of PROMETHEE is based on pairwise comparisons. The intensity of preference or preference index for each pair of alternatives $a,b \in K$, ranges between 0 and 1, from 0 indicating no preference or indifference up to 1 for an outright preference for a over b. When the pairs of alternatives a and b is compared, the outcome of the comparison is expressed in terms of preference as follows:

- P(a,b)=0, if $d \leq 0$ means there is indifference between a and b or no preference;
- P(a,b)≅0 , $d>0$ expresses a weak preference for a over b;
- P(a,b)≅1, $d>>0$ strong preference for a over b;
- P(a,b)=1, d>>>0 outright preference for a over b.

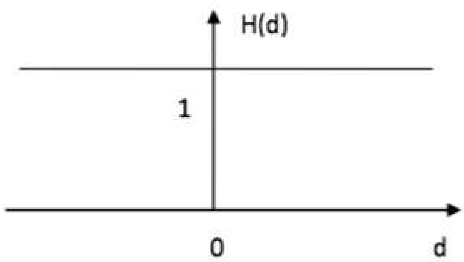
For each criterion f, we consider a generalized criterion defined by f and a corresponding preference function. *P*(a,b) is an increasing function of the difference d, between the performances of alternatives a and b on each criterion and *d* is the deviation between the evaluations of two alternatives on each criterion. In practice P(a,b) represents the difference between the evaluation of the two alternatives so that it can be expressed as follows (Belton & Stewart, 2002)

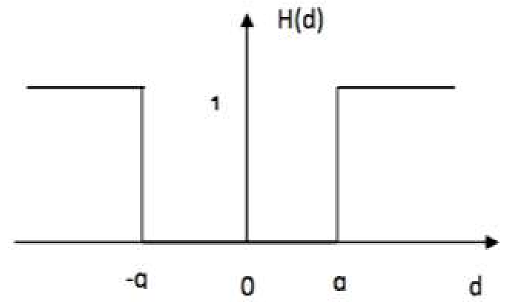
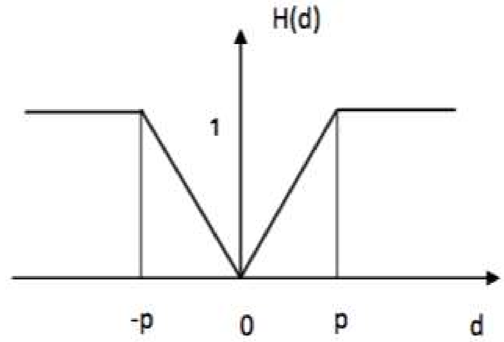
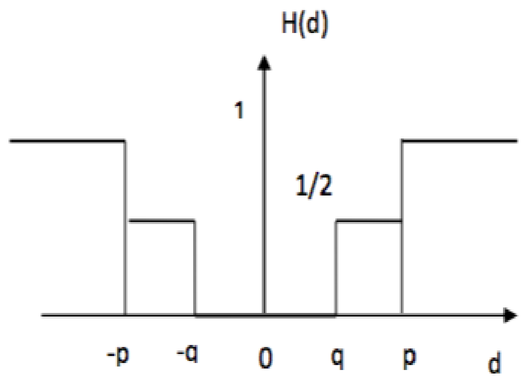
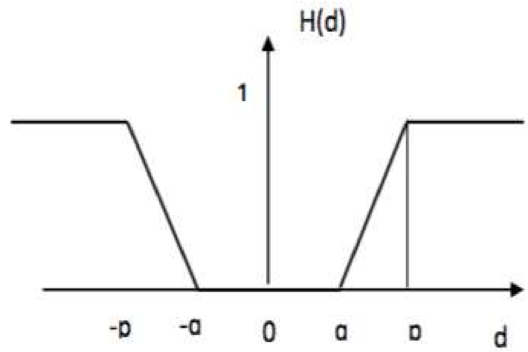
$$P_i(a,b) = P_i\,[d_i(a,b)]$$

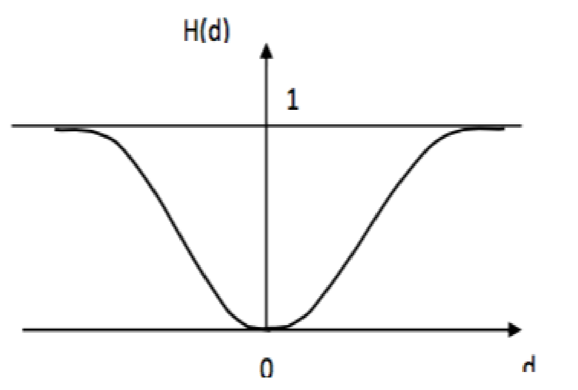
$$d_i = f(a) - f(b) \text{ thus } 0 < P_i(a,b) < 1$$

The preference function can be of different forms, depending upon the judgment policy of the decision maker. Generally, six forms of the P_i function are commonly used, which are graphically represented in the figures below:

Figure 4.1: Forms of the Preference Function

Criterion	Graphical form of generalized criteria	Parameters
I. Usual criterion		-

II. Quasi-criterion		q
III. Criterion with linear preference		p
IV. Level criterion		q, p
V. Criterion with linear preference and indifference area		q, p

VI. Gaussian criterion		σ

Source: (Brans & Mareschal, 1994)

When applying the PROMETHEE II method is usually the decision-maker(s) who is entitled to select the desired shape of the preference function and to specify any parameters that are needed on the basis of the criteria (Belton and Stewart, 2002). The Usual (type I) and Level (type IV) preference functions are best suited for qualitative criteria. In case of a small number of levels on the criteria scale (e.g. yes/no criteria or up to 5-point scale) and if the different levels are considered quite different from each other, the Usual preference function is best suited. While if one wants to differentiate smaller deviations from larger ones, the Level preference function is more adequate.[45]

I. Usual criterion

$$H(d) = \begin{cases} 0 \; if \; d = 0 \\ 1 \; if \; d \neq 0 \end{cases}$$ (46)

In this case, there is indifference between a and b if and only if $f(a) = f(b)$ as soon as the two evaluations are different, the decision maker has a strict preference for the action having the greatest evaluation. In this case, no parameter has to be defined. This generalized criterion corresponds to the usual meaning of criterion.

IV. Level criterion

$$H(d) = \begin{cases} 0 \; if |d| \leq q \\ 1/2 \; if \; q < |d| \leq p \\ 1 \; if \; p < |d| \end{cases}$$ (47)

[45] Source: http://www.promethee-gaia.net/faq-pro/index.php?action=article&cat_id=003002&id=4
[46] Source: Diakoulaki, D., andKoumoutsos, N. (1991). Cardinal ranking of alternative actions: extension of the PROMETHEE method. *European Journal of Operational Research*, 53(3), 337-347.
[47] Source: *ibid.*

In the case of the Level criterion an indifference threshold q and a preference threshold p are simultaneously defined. If d lies between q and p, there is a weak preference situation ($H(d) = 1/2$). The decision maker has this time two thresholds to define.

II. Quasi-criterion

The U-shape (type II) preference function is a special case of the Level one and is less often used:[48]

$$H(d) = \begin{cases} 0 \text{ if } -q \leq |d| \leq q \\ 1 \textit{ otherwise} \end{cases} \quad (49)$$

The two actions are indifferent to the decision maker as long as the difference between their evaluations, i.e. d, does not exceed the indifference threshold q; if this is not the case, there is strict preference. If the decision maker wishes to use a quasi criterion, he/she has only to determine the value of q, which is the greatest value of the difference between two evaluations, below which the decision maker considers the corresponding actions as indifferent.

III. Criterion with linear preference

The V-shape (type III) and linear (type V) preference functions are best suited for quantitative criteria.[50]

$$H(d) = \begin{cases} d/p \text{ if } -p \leq d \leq p \\ 1 \text{ if } d < -p \text{ or } d > p \end{cases} \quad (51)$$

As long as d is lower than p, the preference of the decision maker increases linearly with d. If d becomes greater than p, we have a strict preference situation. When the decision maker identifies some criterion to be of that type, he has to determine the value of the preference threshold p: This is the lowest value of d above which he considers that there is strict preference of one of the corresponding actions.

[48] Source: http://www.promethee-gaia.net/faq-pro/index.php?action=article&cat_id=003002&id=4
[49] Source: Diakoulaki, D., andKoumoutsos, N. (1991). Cardinal ranking of alternative actions: extension of the PROMETHEE method. *European Journal of Operational Research*, 53(3), 337-347.
[50] Source: http://www.promethee-gaia.net/faq-pro/index.php?action=article&cat_id=003002&id=4
[51] Source: *ibid.*

V. Criterion with linear preference and indifference area

$$H(d)= \begin{cases} 0 \; if \; |d| \leq q \\ (|d| - q)/(p-q) \; if \; q<|d| \leq p \\ 1 \; if \; p<|d| \end{cases}$$ [52]

In this case, the decision maker considers that his preference increases linearly from indifference to strict preference in the area between the two thresholds q and p. Two parameters are to be defined.

VI. Gaussian criterion

The Gaussian (type VI) preference function is less often used, as it is more difficult to parameterize, as the function requires the determination of σ, which should be defined between q (indifference threshold) and p (strict preference threshold).

$$H(d)= 1- exp\{-d^2/2\sigma^2\}$$

In the present study, the shape of the $H(d)$ function selected is the Level form which is best suited for qualitative data analysis, when it is necessary to differentiate for smaller range between the values, as in this research.

Weights

Once the preference function Pi (i = 1,2,3, ... k represent the criteria) has been defined the weights of each criterion must be determined. The weights π represent the relative importance of the criteria used, if all criteria are equally important then the value assigned to each of them will be identical (Hermans, 2007). The multicriteria indicator of preference $\Pi(a, b)$, which is a weighted mean of the preference functions $P(a,b)$ with weights πi for each criterion, express the superiority of the alternative a against alternative b after all of the criteria are tested. The values of $\Pi(a,b)$ are calculated using the following equation (Brans and Mareschal, 2005):

$$\Pi(a,b) = \frac{\sum_{i=1}^{k} \pi i \; P_i(a,b)}{\sum_{i=1}^{k} \pi i}$$

Π (a,b) represents the strength of the decision maker's preference for action a over action b considering all criteria simultaneously and Π (b,a) how much b is preferred

[52] Source: Diakoulaki, D., andKoumoutsos, N. (1991). Cardinal ranking of alternative actions: extension of the PROMETHEE method. *European Journal of Operational Research*, 53(3), 337-347.

above a. Its value falls between 0 and 1 whereby (Cavallaro, 2005):

- $\Pi(a,b) \cong 0$ indicates a weak preference for a over b for all criteria;
- $\Pi(a,b) \cong 1$ indicates a strong preference for a over b for all criteria.

In addition to weighting, the PROMETHEE II method involves the setting of so-called thresholds that delineate decision-makers preferences for each criterion. The critical thresholds are defined as the indifference threshold q_i and the preference threshold p_i. When the difference between the evaluations of *a* and *b* is lower than q_i, it is not significant, and the preference of *a* over *b* is thus equal to 0 (Belton & Stewart, 2002). When the difference between the evaluations of *a* and *b* is greater than p_i, it is considered to be very significant, and the corresponding preference is thus equal to 1 (Belton & Stewart, 2002).

Ranking Alternatives

The preference index thus defines a valued outranking relation, which is exploited to determine an ordering of the alternatives. The traditionally non-compensatory models include some for which the preferences are aggregated by means of outranking relations. When each alternative is facing other alternatives the following outranking flows are defined: the positive outranking flow expresses the extent to which *a* outranks all other options (Belton & Stewart, 2002):

$$\varphi^+(a) = \sum_{b \in K} \Pi(a,b)$$

The negative outranking flow indicates how an alternative is outranked by all others (Belton and Stewart, 2002):

$$\varphi^-(a) = \sum_{b \in K} \Pi(b,a)$$

Each of these indices defines a complete pre-order of the alternatives, the intersection of which gives a partial order, as follows ((Belton & Stewart, 2002; Brans & Vincke, 1986):

- *a* outranks *b* if:
  - $\varphi^+(a) > \varphi^+(b)$ and $\varphi^-(a) < \varphi^-(b)$
  - $\varphi^+(a) > \varphi^+(b)$ and $\varphi^-(a) = \varphi^-(b)$
  - $\varphi^+(a) = \varphi^+(b)$ and $\varphi^-(a) < \varphi^-(b)$
- *a* is indifferent to *b* if $\varphi^+(a) = \varphi^+(b)$ and $\varphi^-(a) = \varphi^-(b)$

- a and *b* are incomparable if:
    - $\varphi^+(a) > \varphi^+(b)$ and $\varphi^-(b) < \varphi^-(a)$
    - $\varphi^+(b) > \varphi^+(a)$ and $\varphi^-(a) < \varphi^-(b)$

Finally, the net outranking flow, which is the balance between the positive and the negative outranking flows; the higher the net flow, the better the alternative (Belton & Stewart, 2002: 254):

$$\varphi(a) = \varphi+(a) - \varphi-(a)$$

Accordingly, *a* outranks *b* if φ (a)> φ (b), with indifference φ(a)= φ(b) (Belton & Stewart, 2002:255).

The results are expressed by the preference functions, which are calculated for each pair of options. The weighted preference index is defined by representing the preferences of the decision maker (Belton & Stewart, 2002). Initially, the model assumes that the criteria are equally important. As a further step, the model is integrated with an approach to elicit weights. In the final stage, two alternatives (a, b) are compared with each other and each one is assigned two values of flows (Belton & Stewart, 2002). The positive flow expresses the total superiority of the alternative a against all of the other alternatives for all of the criteria (Belton & Stewart, 2002). The negative flow expresses the total superiority of all of the other alternatives against alternative a for all of the criteria. $\Phi(x)$ is the net flow of each alternative (the difference between the positive and the negative flow) and is used to obtain the final evaluation (Belton & Stewart, 2002).

5 General Features of the Nine Case Studies

5.1 Accra´s city profile and UPA characterization

Accra is the capital city of Ghana, located on the Western coast of Africa. Accra specifically covers an area of about 170 km², with a population of approximately 2.3 million inhabitants (World Bank, 2013b; Government of Ghana[53]), with a growth rate of approximately 3.1% per year (2010 data). The Accra Metropolitan Area (AMA) is the largest urban agglomeration in Ghana. The city has a tropical savanna/semi-arid climate, with low annual rainfall averaging 810 mm distributed over less than 80 days. The annual average temperature is 26.8°C and is relatively stable throughout the year, with March being the hottest (28°C) and August being the coolest (24.7°C) month (World Bank, 2013b).

Accra has a long history of UPA practices and it has been the subject of numerous studies including several types urban and peri-urban farming activities. These are typically along water bodies and drains, and in backyards. All these UPA production systems mainly produce lettuce, cabbage, spring onions, cucumber, green pepper and cauliflower, or the more traditional vegetables as tomatoes, okra, eggplant and hot pepper, and livestock keeping (RUAF[54]; World Bank, 2013b; RUAF/IWMI).[55]The cultivation of crops and rearing of animals in and around households characterized backyard farming. About 50 to 70 ha of agricultural land are distributed around 80,000 backyards involving nearly 60% of households. This may often be limited to just a few plantain or mango trees or chickens, but sometimes could also include a few square meters of maize or cassava (World Bank, 2013b: 52). All plots used for vegetables farming are close to streams and storm water drains since the most profitable vegetables require continuous irrigation (World Bank, 2013b). A 2006 survey estimated that open-space farming extend on about 680 ha under maize, 47ha under vegetables (rain fed) and 251ha under mixed cereal-vegetable systems (RUAF[56]; World Bank, 2013b; RUAF/IWMI).[57] Mushroom production is also practiced in Accra located at the periphery of the metropolitan area. It involves approximately

[53] Source: www.ghana.gov.gh
[54] Source: http://www.iwmi.cgiar.org/africa/West/projects/RUAFII-CFF.htm
[55] Source: http://ruaf.iwmi.org/Data/Sites/4/PDFs/Accra%20Background%20Info.pdf
[56] Source: http://www.iwmi.cgiar.org/africa/West/projects/RUAFII-CFF.htm
[57] Source: http://ruaf.iwmi.org/Data/Sites/4/PDFs/Accra%20Background%20Info.pdf

250 registered mushroom farmers, of which the majority are men and 40% are women, usually above the age of 50 years (World Bank, 2013b: 56). Floriculture and ornamental farming activities also involved a smaller number of farmers, who grow both local and exotic flowers as well as grasscutter farming production (World Bank, 2013b). Commercial livestock farmers rear mostly poultry and pigs (World Bank, 2013b). Whjle due to lack of natural resources, aquaculture is not largely practiced in the city, but it is the farming activity dominated by women (80%) having basic education.

In Accra, there is no specific policy against the practicing of UPA, and UPA related issues currently fall under the jurisdiction of different types of authorities (e.g. Ministry of Food and Agriculture (MoFA), Town and Country Planning, Forestry, Parks and Gardens, Public health department, Urban planning, etc.) (World Bank, 2013b). Smallholder agriculture development is highlighted almost in all major policy, programs and projects such as Ghana Poverty Reduction Strategy, Modernization of the Capital City and Decentralization Policy. Nevertheless, this has not yet enhanced the development, widespread legalization, and the governmental support for UPA (World Bank, 2013b).

5.2 Nairobi´s city profile and UPA characterization

Nairobi is Kenya's political and economic capital.. Nairobi's population has grown up to over 3 million in 2009, which makes it the most populous city in East Africa and the 12th largest city in Africa (World Bank, 2013b). The city has continued to experience an increase in population due to new immigrants. Nairobi is at an elevation of 1,795 meters, which contributes to its moderate climate. The city is classified as having a subtropical highland climate. The annual average temperatures are a high of 23.4°C and a low of 12°C. Rainfall on average is about 1,024 mm (40.3 inches) annually (World Bank: 2013b: 67). It is popularly known as the "Green City in the Sun" (World Bank, 2013b: 66).

With thousands of kilograms of crops, such as maize, beans, and vegetables, being produced annually, urban farming and livestock practices play a key role in the city economic activities (World Bank, 2013b). UPA is practiced in backyard farms, on open spaces under power lines, along roadsides, railway lines and riverbanks as well as on institutional land (World Bank, 2013b). In the mid-1980s, when the city's population was around 1 million, 20% of Nairobi households were growing crops and 17% kept livestock (World Bank, 2013b) and it is estimated that more than 650 hectares of land in Nairobi is under urban and peri-urban production (World Bank, 2013b: 14). Since the 90s, extensive research has been conducted on UPA practiced in the country, however, no central government or policy support existed back then. Local authorities in Nairobi and other towns were rather hostile, and only NGOs were actively supporting projects, like for instance the Consultative Group on International Agricultural Research's (CGIAR) Urban Harvest research that in 2002 started a project on recycling nutrients from organic wastes in Nairobi. These local initiatives, however, set into motion the interest of the public sector, which resulted in a series of policy initiatives, farmers' networks, like the Nairobi and Environs Food Security, Agriculture and Livestock Forum (NEFSALF) (Lee-Smith, 2010: 495). Thanks to the numerous initiatives the Nairobi province was selected to launch the second phase of the National Agriculture and Livestock Extension Programme (NALEP) in 2006 (Lee-Smith, 2010). UPA has started to be integrated into the National Land Policy, adopted by Parliament in 2010 (Lee-Smith, 2010). The Ministry's extension service provides training for farmers, and recently launched a US$2.3 million project to promote urban and peri-urban agricultural cooperatives in Nairobi (FAO, 2014). Late in 2011, the Ministry was reported to be finalizing a national Urban and Peri-urban Agriculture and Livestock Policy to guide the full integration of agricultural activities in urban areas (FAO, 2014).

5.3 Kampala´s city profile and UPA characterization

Kampala, the capital city of Uganda, is a reflection of the historical, political, and economic transformations happened in the country starting with the economic decay and civil wars in the 70s and 80s (Vermeiren, Van Rompaey, Loopmans, Serwajja, & Mukwaya, 2012). The city comprises approximately 25% of Uganda's urban population, and about 5% of Uganda's total population (Uganda Bureau of Statistics 2014)[58]. Kampala is also the centerpiece of the country´s economic, political and social transformation, and alone contributes to a quarter of Uganda's economy (Vermeiren, Van Rompaey, Loopmans, Serwajja, & Mukwaya, 2012). The climate of the city as for the rest of the country is tropical characterized by ample rainfall.

58 Source: http://www.ubos.org/2016/03/24/census-2014-final-results/

In Uganda the agricultural sector accounts for 90% of the country´s exports, and for 80% of employment. About 64% of Uganda´s gross domestic product is in the form of food crops mainly produce by around 3 million farm households of which 80% have less then 4ha of land (David et al., 2010: 97). In the early 90s UPA was widespread in Kampala. The most commonly grown crops are banana, cassava, maize, beans, vegetables and fruit (i.e. leafy greens, cabbage, tomatoes, onions, sweet potatoes, potato, cocoyam, sugarcane) (Sabiiti et al, 2014). UPA is practiced in diverse locations including home compounds, along roadsides, in wetlands/swamps, under power lines, and on waste dumpsites (Sabiiti et al, 2014). Public lands - roadsides, open spaces, wetlands, and around power lines and infrastructural projects - are used illegally, with no or informal tenure arrangements (Sabiiti et al., 2014: 14). Kampala's farming households comprises of four types: commercial farmers, food self-sufficiency farmers, food security farmers and survival farmers (Sabiiti et al., 2014: 13):

- *Commercial farmers* are few and generally well off. They are found mostly at the peri-urban periphery, and produce almost entirely for the urban market;
- *Food self-sufficiency farmers* are also mostly well off, and are found in all areas except the inner urban core;
- *Food security farmers* are among the middle-income or well-off households in the urban areas, but among the poor in peri-urban areas. These households practice UPA as a secondary form of employment as well as a source of food. They have other sources of income with farming helping them to save or supplement urban lifestyles;
- *Survival farmers* include a very large number of people. The majority are female-headed households with very limited economic options. They mainly operate in urban areas (David et al, 2010).

Several historical factors influenced how UPA and its related policies took shape in Kampala. In 1988, in the aftermath of the civil war, a group of Ugandans started a non-governmental organization called Environmental Alert to combat food insecurity and poverty in country (Lee-Smith, 2010: 493). Urban areas such as Kampala were designated as districts, with Kampala City Council having a Department of Agriculture integrated with the Ministry of Agriculture. In 2005, the Mayor of Kampala passed –a regulation allowing urban dwellers to cultivate land and rear animals within the city borders (Cofie, van Veenhuizen, & Drechsel, 2003), following in 2006, the city council passed additional new ordinances on UPA following a participatory process of public consultation. In 2009, the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF) was allocated a budget for the development of an UPA policy within government's five-year Development Strategy and Investment Plan (Lee-Smith, 2010).

5.4 Rosario´s city profile and UPA characterization

With 1.35 million inhabitants and another 200,000 people residing in the peri-urban areas Rosario is a large city. The Rosario metropolitan area is Argentina's third largest urban agglomeration and one of its most prosperous, with an urban area of approximately 120.37 km^2, with only 11.27 km^2 devoted to green spaces.[59] Rosario was an industrial city in a nation whose economy had collapsed. Many of the city's steel, chemical and paper factories closed, and one-third of the workforce was unemployed. In December 2001, around 60% of the population had incomes below the poverty line, 30% were living in extreme poverty, and hyperinflation had increased the price of staple foods four times over (World Bank, 2013b: 81). The governmental policy support for UPA initiatives was thus a response to the country´s economic crisis (World Bank, 2013b). In February 2002, the municipal government launched an urban agriculture programme to foster small-scale, self-production of fresh food, mainly in low-income urban and peri-urban areas. Urban areas dedicated to agriculture were established and have been maintained since then. UPA in Rosario has evolved along with Argentina's economic recovery (World Bank, 2013b). Rosario is one of the very few cities in which the municipality actively supports the integration and finances the development of urban agriculture (FAO, 2007). Today, urban green space is distributed in 24 parks, 124 squares, 51 squares, 24 walks and 228 other green spaces. Their total area is 11,264,550 m^2 (11,265 km^2), 6.3% of the total area of the city.[60]

Under its Metropolitan Strategic Plan 2008-2018, Rosario is building a "green circuit" consisting of family and community gardens, large-scale, commercial vegetable gardens and orchards, multifunctional garden parks, and "productive barrios", where agriculture is integrated into programmes for the construction of public

[59] Source: http://www.rosario.gov.ar/web/ciudad/caracteristicas/informacion-territorial-y-datos-demograficos . Accessed on January 2017.
[60] Source: *Ibid.*

housing and the upgrading of slums (World Bank, 2013b:87). In 2014, the green circuit consisted of more than 30 ha of land used to grow vegetables, fruit and medicinal and aromatic plants (World Bank, 2013b).

5.5 Lima´s city profile and UPA characterization

Peru's capital Lima is the biggest city, home to one third of Peru's population. The Lima Metropolitan Area has grown rapidly since the second half of the 20th century, when people started migrating to the city looking for better livelihood opportunities. Lima has a total population of approximately 9.262.000 people, with the Lima Metropolitan Area having a population of 8,445,200, accounting for 30.8% of the whole country´s population (World Bank, 2013b). The city´s climate is considered to be subtropical. The average annual high and low temperatures are 22°C and 16.7°C respectively. Lima gets an average of 13 mm (0.5 inches) of rain a year, which impacts the amount of water supplied to the city, which mainly comes from wells and rivers originating in the Andes mountain range (World Bank, 2013b). The city is also severely impacted by El Niño, and La Niña (World Bank, 2013b).

Despite the accelerated urban growth in the last few years, agriculture is still being practiced in the areas around Lima and to a lesser extent within the city itself. According to the records of the Chillón, Rimac, and Lurin rivers in 2006 there was a total of 12.680 ha under irrigation belonging to 7.601 farmers organized in 35 commissions responsible for river water irrigation (World Bank, 2013b: 79). The most important crops grown are vegetables, grass, and forage; fruit orchards, vegetables, ornamental plants, and maize and aromatic plants (World Bank, 2014). On a much smaller scale, urban agriculture is also carried out in small spaces, such as patios, flower pots, small public spaces, ranging from $1m^2$ to $10.000m^2$. The crops grown in these areas are mostly used for home consumption and usually no chemicals are used in the cultivation (World Bank, 2013b: 79).

For many years, in Lima the institutions most active in promoting urban and peri-urban agriculture were NGOs, research centres, international organizations and some private companies (FAO, 2014). Their activities persuaded the local governments of Lima's Villa María del Triunfo, Chosica Lurigancho and Villa el Salvador districts to incorporate UPA in their urban development programs, sometimes as part of civic beautification projects (FAO, 2014). A recent positive development also consists in the adoption by the Metropolitan Lima Municipal Council (September 2012) of an ordinance for the promotion of UPA, which it defines as "a strategy for environmental management, food security, social inclusion and local economic development" (FAO, 2014). Notwithstanding, there is still no clear national public policy that recognizes and promotes urban and peri-urban agriculture or regulates its incorporation into the overall strategic planning of Peruvian cities (FAO, 2014).

5.6 Havana´s city profile and UPA characterization

The Province and city of Havana is the island's capital and political-administrative and economic center. It is the largest city in the island and the second largest in the Caribbean, after Santo Domingo. With just over 2 million inhabitants (2012) (100% urban), the city of Havana covers 727 km², namely 0.67% of the country's territory.. The climate is tropical, with mean annual temperature 25,2°C, relative humidity 79% and annual average rainfall 1400 mm, which makes it a city with good conditions for engaging in tropical urban agriculture.

Urban agriculture in Cuba as well as in Havana has emerged as a response to the economic crisis of the 1990s in the early years of the "Special Period" and evolved from a "crisis model" to a "permanent model" characterized by a local focus, diversity of economic actors, and relative decentralization,[61] an alternative to the input-intensive, state-centric, agricultural production model implemented since the early days of the 1959 revolution (Koont, 2009). In its initial stage UPA was performed as an unstructured and ad-hoc activity. Indeed, Cuba's urban agriculture movement was brought to the forefront in 1997 when then Minister of the Armed Forces (FAR), Raúl Castro, declared a "National Urban Agriculture Day", but formally recognized by the Ministry of Agriculture in 1998 (FAO, 2013b). This official recognition resulted in the creation of the National Group for Urban Agriculture in an effort to institutionalize the country's ad hoc UPA´s movement (Koont, 2009). Later on, in 1999, Havana's Physical Planning Directorate recognized UPA as a permanent form of agricultural production.[62] Cuba's National Urban Agriculture Program includes 28 sub-programs, specialized in the production of specific crops and livestock (FAO, 2013b). The predominant productive units that participate in the urban agriculture subprograms

[61] Source: http://www.ascecuba.org/asce_proceedings/urban-agriculture-in-cuba-an-update/ (Accessed December, 2016).
[62] Source: *Ibid.*

are: auto-consumption plots; producers of protected crops; backyard plots and parcels; intensive orchards; and organopónicos (FAO, 2013b). The total area under agriculture in Havana is estimated at some 35.900 ha, and includes 97 organopónicos, 700 diversified farms, 170 livestock farms, 27 forested areas, 2 provincial enterprises specialized in porcine livestock, 20 Unidades Básicas de Producción Agropecuaria (UBPC) (Basic Units of Cooperative Production), 91 Cooperativas de Créditos y Servicios (CCS) (Credit and Services Cooperatives) (FAO, 2013b).

5.7 Kesbewa`s city profile and UPA characterization

Kesbewa is situated about 21 km south of Colombo, in the Colombo District, Western Province of Sri Lanka. With almost 6 million people, the Western Province is the most urbanized province in Sri Lanka, home to about 25% of the total national population (Mohamed & Gunasekera, 2014). As a result of the continuous growth of Colombo and expansion of the urban boundaries of Colombo Metropolitan Region, Kesbewa Urban Council (KUC) became an attractive residential area, hosting over 244.000 inhabitants (data stemming from the 2012 census) (Mohamed and Gunaseker, 2014: 20). The KUC is located in the Low country Wet zone classified and is characterized by four rainy seasons: a first Inter-monsoon period from March to April; the Southwest Monsoon period from May to September; the Second inter-monsoon period from October and November; and the Northeast monsoon period from December to February (Mohamed & Gunasekera, 2014). During the Southwest monsoon period, the area receives more than 500 mm rainfall/month, while during the second inter-monsoon and the northeast monsoon periods, the area receives more than 200mm average rainfall per month (UN-HABITAT, 2011a). The average air temperature of the KUC area (2008 to 2013) was 28.05°C. During the Southwest Monsoon period average temperature is relatively low when compared with the first inter monsoon period and the northeast monsoon period[63] (University of Colombo, 2014).

Historically, Kesbewa has been an agricultural area endowed with the excess water resources of the bordering Bolgoda Lake. However, the area is currently characterized by high and rapid conversion of agricultural land to urban land uses,

[63] Source: University of Colombo (2014): Land surface temperature variations in Kesbewa Urban Council area, Sri Lanka. Report produced fort he RUAF Foundation.

resulting in about 60% of the land now being used for others purposes (Mohamed & Gunasekera, 2014), while 32% of land is still being used for agriculture (UN-Habitat, 2014a). In 2011, Kesbewa counted with 600 hectares of paddy lands, with 32% of the total paddy areas being abandoned (UN-HABITAT, 2011a), and a total of 410 hectares was used for home gardens, mainly located in low-density residential areas (Dubbeling, 2014).

Recently, authorities at the local level with the support of international institutes have started promoting the integration of urban agriculture into the Kesbewa Urban Development Plan (preserving low-lying lands for urban agriculture and designing such areas based on the results of the pilot projects) and, in the municipal programs and budgets providing financial incentives for rainwater harvesting in home gardens or for rehabilitation of drainage canals in paddy areas (Mohamed & Gunasekera, 2014). At the national level, a revision of the "Paddy Act" was undertaken under the supervision of the Department of Agrarian Services, Ministry of Agriculture (Mohamed & Gunasekera, 2014). This revision aims to promote and support new models and forms of production of mixed cultivation of rice and vegetables that will increase income, promote and revalorize agro-ecological forms of production and maintain natural drainage functions of the areas (Mohamed & Gunasekera, 2014).

5.8 Hanoi´s city profile and UPA characterization

Hanoi is the second largest province of Vietnam situated in the Red River Delta. It is the center of political, economic and cultural activities of the country. Population growth over the last 20 years has been significant (between 1996-2001, the city's population grew by 3.2% (Vien, Quang, Dung, & Gia, 2005). In 2009 the province spread over a total area of approximately 928 km^2 with a population of approximately 6.452 million people (2009), and a population density in some parts reaching 3.100 persons per km^2 (Lee, Binns, & Dixon, 2010). Like in the Southeast Asia region, Hanoi has a typical tropical climate with a monsoon rainy season from May to September, a cool dry season from October through January when the average temperature drops to about 10-25°C, and hot dry season from February to April when the temperature can reach as high as 40°C. Most of the rain comes from May to September while October to March is almost dry.

Hanoi has been under communist rule since the defeat of the French in 1954. During the American War, farmers were required to grow whatever the government demanded in order to maintain the war effort. After the war, farmers were told what produces to grow and they worked collectively on government-run farms (Lee, Binns, & Dixon, 2010). The Doi Moi reforms, in 1986, represented a significant shift, and its most notable effect on the agricultural sector was that producers could work on their individual plots, growing crops of their choice and selling them (Lee, Binns, & Dixon, 2010). This transformed the nature of farming practices in Hanoi, with many people started experimenting different crop types and investing in a range of new production strategies (Vien, Quang, Dung, & Gia, 2005). Even though, since the late 1980s, the share of agriculture declined from 10% to about 3.6% (1999), but the sector still plays an important role in the supply of food and the provision of income (Phuong, Ali, Lan, & Ha, 2004). In 2000, about 49% of the total surface of Hanoi province was used for agriculture (Van den Berg, van Wijk, & Ho Pham, 2003). Cereals, vegetables and pulses are the major crop groups grown in the city. Maize is the second major cereal crop and is grown mainly on alluvial soils (Phuong, Ali, Lan, & Ha, 2004). Vegetables are an important part of the cropping system and are grown on about 9% of gross sown area (Phuong, Ali, Lan, & Ha, 2004). Pulses are next to cereals and vegetables in terms of importance in peri-urban Hanoi. Starch food crops, such as sweet potato and cassava, follow them (Phuong, Ali, Lan, & Ha, 2004). A large number of animal populations are also reared in Hanoi to supply livestock products to city residents (Phuong, Ali, Lan, & Ha, 2004). Aquaculture production extends on 3.415 ha (2001) with the majority of the area under fish production while the remaining is used for shrimp (Phuong, Ali, Lan, & Ha, 2004).

5.9 Phnom Penh´s city profile and UPA characterization

Phnom Penh is the capital city of Cambodia with a population (2012 estimated) of approximately 1.5 million, 54% of the urban population of Cambodia and 11% of the total (UN-DESA, 2013). Phnom Penh is expected to add another nearly one million inhabitants by 2025 (UN-HABITAT, 2010). Phnom Penh municipality consists of eight districts, or khans, including 96 sub-district communes (sangkats) and 897 villages, for a total land area of 680 km^2 (Underhill, 2013)· The city is surrounded by wetlands and its climate, like that of the rest of Southeast Asia, is dominated by the monsoon, with the rainy season from May to October and the dry season from November to

April, the latter being the hottest periods of the year (Underhill, 2013). Total annual rainfall average is between 100 and 150 cm, with the heaviest fall in the southeast (Underhill, 2013).

Because few systematic studies have been conducted on UPA practices in Phnom Penh, the most readily available data are not too recent and mainly based around the cultivation of aquatic plants in wastewater lakes around the city (Underhill, 2013). Agrisud International (1999) provided an overview of the production systems in Phnom Penh, including following crops in the high lands, like fruits (banana, coconut, jackfruit, mango); in high chamcar, vegetables: chinese kale, Chinese cabbage, cabbage, chives, salad, mustards, chillies, ginger; in low chamcar, including sweet potato, sugar cane, mungo bean, maize, groudnut, ginger, yam, taro; and in the lowland, rice maize, beans.[64] In 2001, according to the statistics of the ministry of agriculture, the total area cultivated in Phnom Penh municipality was 7.500ha of rice and 765ha of vegetables (Moustier, 2001) with the Saang district being the largest district in terms of vegetable production, followed by the Kien Svay (1000 hectares of vegetables), located 25 km from the city (Moustier, 2001).

[64] Source: Agrisud International (1999) Programme d´appui au dévelopment des activités agricoles périurbanes autour de Phnom Pehn,. Etudié de faisabilité. Tome 1, 76pp.

6 The PROMETHEE II analysis

6.1 Applied indicators & evaluation scale

To conduct the evaluation of the nine cities with the PROMETHEE II method, it has been necessary to gather and structured a multitude of data and information. This process has been conducted through the MAXQDA software. Specifically, the software enabled the application of a coding approach resulting in the disaggregation of and extraction of quantitative triple-wins data about UPA`s practices then organized into three main datasets, one for mitigation, one for adaptation and one for sustainable development criteria, as displayed in Table 6.1:

Table 6.1: Triple-wins coding datasets

Mitigation coded criteria	Reduction of GHG emissions
	Landfill volume
	Carbon sequestration
	Use of chemical fertilizers & pesticides
Adaptation coded criteria	Incidences of floods/erosions
	Wastewater for irrigation
	Reduction of the Urban Heat Island (UHI) effect
Sustainable development coded criteria	Food security & accessibility
	Diets and nutrition
	Food prices
	Income/employment generation
	Inclusion of marginalized groups

Source: own elaboration

The MAXQDA software enabled first the coding of the gathered data and information through the development of specific criteria´s codes, secondly the conversion of these criteria´s codes into a harmonized value scale necessary for the analytical comparison of the nice cities performed through the PROMETHEE II method. Furthermore, the innovative MAXQDA statistical features have allowed to compute frequency distribution tables for each criterion and for each case study, as reported in Appendix II. The relative frequencies (not accounting for documents reporting no code/criteria) were then translated into a 9-points qualitative scale, ranging from *"very bad"* to *"very good"* as displayed in Table 6.2. The 9-point scale was specifically applied to better account for the small differences reported in the calculated relative frequencies of each criterion, which aims to guaranteeing a better analytical representation of existing UPA`s triple-wins impacts in each analyzed case study.

Table 6.2: 9-point qualitative value scale

	9-points scale	***Relative frequencies distribution***
9	Very bad (VB)	0-11%
8	Very bad – bad (VB – B)	12-23%
7	Bad (B)	24-35%
6	Bad – Average (B- A)	36-47%
5	Average (A)	48-59%
4	Average – Good (A-G)	60-71%
3	Good (G)	72-83%
2	Good – Very Good (G-VG)	84-95%
1	Very Good (VG)	96-100%

Source: own elaboration

6.2 Applied weighting approach and scenario

In MCDA analyses, the simplest but also the most arbitrary technique to assign weights is direct assignment, where decision-maker(s) set(s) the weights (Belton & Stewart, 2002). Others techniques require a more direct collaboration between the decision-maker(s) and the analyst(s) for instance to obtain a vector of weights that conforms as closely as possible to decision-makers' preferences, defined as "swing weighting" (Belton & Stewart, 2002). To assign values to the weights the decision-maker must assess the relative value of the swings (Belton & Stewart, 2002). Another widely used process is the application of the AHP method that creates a pairwise comparison matrix (Belton & Stewart, 2002). Nevertheless, being this study based on secondary sources data and aiming at the evaluation of existing UPA`s triple-wins impacts on the ground, an ex-post evaluation rationale has been applied. Accordingly no decision-makers preferences were reported and no relative weights included. All criteria have been treated equally reporting a weight's value of 1.

Similarly no diversified scenarios were used, but rather a single scenario accounting for the status quo in the nine analyzed cities.

7 The PROMETHE II Results

7.1 Urban and peri-urban agriculture in the nine case studies

Table 7.1 presents the evaluation of the case studies as obtained from the net flows with no weighting and a single scenario situation. While Table A3.1 and Table A3.2 in the Appendix III present the performance matrix of each case study in relation to each criterion, and the unicreterion net flow values to evaluate the relative performance of an action on any criterion, ranging between -1 (worst possible value) and +1 (best possible value).

Table 7.1: Ranking of the nine case studies

	Case Study	Net Flow
1	Rosario (Argentina)	0,0521
2	Nairobi (Kenya)	0,0417
3	Lima (Peru)	0,0208
4	Kampala (Uganda)	0,0000
5	Accra (Ghana)	0,0000
6	Hanoi (Vietnam)	-0,0104
7	Phnom Penh (Cambodia)	-0,0104
8	Havana (Cuba)	-0,0104
9	Kesbewa (Sri Lanka)	-0,0833

Source: own elaboration

According to the obtained values of the new flow, the nine case studies can be divided into three main groups:

1. A first group characterized by positive net flows (close to 0) consisting of: Rosario, Nairobi, and Lima;
2. A second group with net flows equal to 0 comprising of Kampala and Accra
3. A third group with negative net flows including Hanoi, Phnom Penh, Havana and Kesbewa.

Starting with the sustainable development dataset, one notices that the criterion income/employment generation is showing higher values in comparison with all others criteria. The relative performance of Nairobi for this criterion is the best, followed by Rosario, Lima, Kampala, Accra and Kesbewa, which have values of 0, all reporting the same values on the 9-point values scale. With respect to the city of Nairobi the higher value can be explained by the higher availability of data and information. Already in 1993, (House, Ikiara, & McCormick, 1993) found that urban and peri-urban agriculture provided the highest self-employment earnings in small-scale enterprises and the third highest earnings in all of Kenya. Following in 2002, (Mireri, 2002) showed that commercial urban livestock, in particular poultry farm could generate a net profit of about US$9.333 per year; while a pig farmer could earn a net profit up to US$2.667 per year (Mireri, 2002). Irrigated urban farming could also significantly contribute to generate higher income in the range of US$1.770 average revenue per hectare (Cornish & Kielen, 2004). Another study in 2005 reported that the typical net monthly income of mixed vegetables producers in Nairobi ranged from US$10 to US$279 (Drechsel et al, 2005). Estimates as for 2013 accounted for approximately 300.000 households - perhaps as many as 1.18 million people - partly depending on urban agriculture for income (World Bank, 2013b).

The others two African cities, namely Accra and Kampala, also provide interesting figures. For Accra, in 2006, (Drechsel et al, 2006a) estimated that up to 60% of farmers, involved in irrigated vegetable cultivation, relied solely on it as a source of income (Drechsel et al., 2006a). The authors also estimated that the typical net monthly incomes of mixed vegetables producers in Accra ranged from US$40 to $50, significantly higher then the general net income (GNI) per capita, estimated at monthly US$27. In 2012 a FAO´s study pointed out that 600.000 households benefited through consumption and/or sale of their produces in Accra (FAO, 2012b). These high figures were further confirmed by a World Bank´s survey in 2013 in which out of 138 open-space farmers interviewed more than 60% rely on irrigated vegetable cultivation as their only source of income, while for 33% of them, UPA represented a supplementary source of income (World Bank, 2013b). In Kampala, in the early 1990s the informal sector activities including urban and peri-urban farming provided 66% of employment and 25–36% of households in the city were engaged in UPA practices (World Bank, 2013b). Studies revealed that 70% of farming households’ heads earn more than national annual income per capita estimated at

US$330 (Mougeout, 2000).[65] A decade later (David et al, 2010) placed that figure at 49%, including as many as 20–25% of the residents of densely populated urban areas, and more than 50% in peri-urban areas (Sabiiti et al, 2014).

Although not as precise as in the African case cities, estimates for Rosario, Lima and Kesbewa also indicate significant UPA´s contribution in particular with respect to employment generation. In Rosario, in 2013, there were 400 gardeners involved in UPA practices, 280 of them producing food for the market and 120 for own consumption (Piacentini et al, 2015). Following a 2014 World Bank´s study reported 1.800 city residents practicing horticulture (World Bank, 2013b). For the city of Lima partial or district-based data are available, indicating a proportion of 0·20 of the urban population involved in UPA activities in 2007 (IPCC, 2007a). More recently (2011) it has been estimated that 7% of producer household heads in urban area m and 20% in peri-urban areas claimed agriculture as their primary occupation (Prain, Karanja, & Lee-Smith, 2010). Conversely, the data available for Kesbewa are derived from the implementation of two projects focusing on home gardens and requalification of abandoned paddy lands (in low-lying flood zones), which indicated higher income and employment opportunities for the farmers involved (Dubbeling, 2014). However, considering the strong project related nature, these data should be considered with caution.

Remarkably, Havana, Hanoi and Phnom Penh have negative values on the criterion "generation of income/employment". In 2014 for the city if Havana, estimates indicated that 90.000 residents were engaged in some form of agriculture (FAO, 2014). However, no precise data exist for generation of income for farmers/households or individuals derived, due to the complex socialist system and reforms implemented for the markets' system in the whole country (FAO, 2014). For Hanoi, there are relatively few reliable figures available with respect to employment rates, and no recent data assessing income generation. According to a survey conducted by the University of Hanoi in 1998, 77.6% of the households were engaged in agriculture; however only 15.2% consider agriculture as their only source of income (FAO, 2014). Out of the same survey it emerged that about 100.000 people, or more than 10% of the labor force, were engaged in food processing activities and an uncountable number of traders (mostly women) earned their living from food vending (Quang & Argenti, 1999). Afterwards, in 2000 it was reported that

[65] Note: for Kampala, the majority of cited studies are more than a decade old and should be considered with the due caution.

nearly 194.000 households (an estimated 829.000 people) obtained an important part of their income from the UPA sector (van den Berg, 2002). Estimates for Phnom Penh about UPA´s contribution to "generation of income and employment" are even less precise. The only available data concerns certain produces and districts, like for instance the data about the Kohkloung Island (Chamcar Maun District), which with its specialized vegetable production employs approximately 200 families in 2005 (FAO, 2007).

The unicriterion preference flows table also provides an interesting picture for the criteria "food security/accessibility", "diets and nutrition", and "food prices". All of the nine cities have a net preference flow of 0 indicating no preference of one of the city over the others. These results, however, in particular for the criterion "food security/accessibility" should not be interpreted as lack of UPA´s contribution, but rather as an indication that the amount of data identified for each city is not substantially different from the others. Looking at "food security and accessibility" in Nairobi, for example, in 2003 the farming households produced 20-35% of their food requirements, and were significantly less dependent on international gifts and transfers (Foeken & Mwangi, 2000; Cofie, van Veenhuizen, & Drechsel, 2003). In 2005, another study reported that as much as 50% of food consumed by low-income groups comes from urban and/or peri-urban agriculture (Argenti and Marocchino, 2005). In the same year, the Ministry estimated that up to a quarter million chickens were reared within Nairobi, about 45.000 goats and sheep, and about 42 million liters of milk were produced within Nairobi´s borders annually (Ayaga, Kibata, Lee-Smith, Njenga, & Rege, 2005: 1). In Kampala, UPA practices also supply food for home consumption: estimates from different years reported that urban producers obtained between 40% to 60% or more of their household food needs from their own gardens (David et al, 2010; Sabiiti et al, 2014). A series of studies coordinated by the CGIAR's Urban Harvest Initiative (between 2002-2004) found that the volume of crops and animal products of UPA represented approximately 40% of the urban annual food requirement in Kampala (Moustier & Danso, 2006), and that the majority of people grew crops or kept animals either to reduce spending on food or simply to prevent starvation (FAO, 2012b). More recent findings by Sabiiti et al., (2014) confirmed these earlier estimates, revealing that 70% of the surveyed farmers engaged in UPA mainly to contribute to household food security (Sabiiti et al., 2014: 17).

In the Latin American region, the importance of UPA for food security and accessibility is particular significant in Havana, where these practices emerged in response to the food crisis after the fall of the socialist bloc in the 90s. During 1996, Havana's urban farms provided the city's urban population with 8.500 tons of agricultural produce, 4 million dozens of flowers, 7.5 million eggs, and 3.650 tons of meat (Companioni et al, 2002). Between 1997 and 2003, vegetables produced in Havana increased from 21 tons to 254 tons (FAO, 2014). In 2009, the total production of vegetables in the city amounted to 285.166 tons (FAO, 2014). In 2010 estimates reported 1.230.300 tons of food (between January and November 2010) generated through urban and peri-urban farming practices.[66] In 2013, it was estimated that the production by all types of entities engaged in urban agriculture in Havana was 63.000 tons of vegetables, 20.000 tons of fruits, 10.5 million liters of milk, and 1.700 tons of beef, pork, and poultry (FAO, 2014).

Data for the Asian cities are also interesting, especially with respect to UPA´s contribution to food security and accessibility in Hanoi. In 2004, (Phuong, Ali, Lan, & Ha, 2004) estimated that about 500.000 tons or about 44% of Hanoi's annual food requirements were supplied by domestic production within the city borders (both urban and peri-urban). About 38% of the food consumed by farm families comes from their own commercial production, and an additional 5% comes from home gardens (Phuong, Ali, Lan, & Ha, 2004; Mubarik, de Bon, & Moustier, 2005). A year later, in 2005,, it was reported that about 76% of cereals, 18% of aquatic food, and 11% of vegetables come from commercial urban and per-urban farming production, while 21% of eggs and milk, 15% of fruits, and 12% of vegetables consumed by farm families comes from home gardens (Mubarik, de Bon, & Moustier, 2005). Notwithstanding, in Hanoi studies also indicated that the generation of produces from UPA practices is not sufficient, and there is a 56% gap between UPA production and Hanoi´s food demand (Phuong, Ali, Lan, & Ha, 2004).

UPA can also play a key role in improving households' diets and nutrition. In Nairobi researches carried out in 1999, in the slum of Korogocho, showed that UPA could improve the nutritional status of households. A group of farmers was compared to a group of non-farmers (with comparable household income levels): the farmers regarded their food situation as better than non-farmers (Cofie, van Veenhuizen, & Drechsel, 2003). This was additionally confirmed by a higher energy intake (100

[66] Source: *Ibid.*

kcal/consumer unit/day) originating entirely from their own production, and a lower percentage of children stunted or severely malnourished (Cofie, van Veenhuizen, & Drechsel, 2003: 3). In 2007, in Kampala, households involved in UPA reported greater nutritional status, measured by caloric and protein intake and anthropometric measurements (stunting, wasting) (FAO, 2007). Children younger than five in low-income farming households were found to be significantly better off nutritionally than their counterparts in non-farming households (Cofie, van Veenhuizen, & Drechsel, 2003). Statistical studies undertaken between 2003 and 2005 confirmed that keeping urban livestock could benefit households in terms of nutritional status (Cole, Lee-Smith, Nasinyama, Harvest, & Lima, 2008: 104). It should be noticed, however, that many available studies have a limited focus on slums or single districts, like in the case of Accra, Lima or Phnom Penh, and therefore in these cities UPA´s contribution to improved diet and nutritional status should be considered with due caution. For example, for Accra (Armar-Klemesu & Maxwell, 2000) assessed that in the city only about 1% of food at the household level comes from direct production in urban agriculture. In farming households, in terms of value and calories, about only 7.5% of total food originates from urban farming. These initial findings were also confirmed from a study by (Maxwell, Levin, Armar-Klemesu, Ruel, Morris, & Ahiadeke, 2000) in which it was assessed that households receive only between 7 to 8% of their total food in terms of value and calories from their own production. Additionally, no positive association of urban farming with child nutritional status was found for Accra (Maxwell, Levin, Armar-Klemesu, Ruel, Morris, & Ahiadeke, 2000). For Lima in 2014 a World Bank´s survey reported estimates in terms of accessibility to "desired food" and not in terms of improved diets, indicating that approximately 35% of both non-producers and producers eat enough of what they want; 23% of producer households consumed at least one food from their own production on the day prior to the survey; and 30% of households even reported to consume food obtained from outlets, such as restaurants or kiosks thus pointing out that UPA is often not the only source of food even for producers (World Bank, 2013b). Limited data for Phnom Penh indicated that in 2001 UPA helps to meet meat and fish consumption needs: the department of agriculture estimated fish consumption at 11 kg/head/year (i.e. 10.731 tons of fish per year) (assuming no change in fish production from 1998 to 2001, in 2002) of which 57% was cover by urban agriculture (Huy & Moustier, 2005: 8).

The sustainable development criterion "food prices" also reported a unicriterion preference flow equal to 0 for all cities. Data with respect to this criterion are scattered. For Hanoi findings in the literature indicated that UPA´s produces enable low price differentials between the farm and final consumption, due to the proximity to the city and the short marketing chains. In 2004, such differentials were 30% for leafy vegetables traded; 35% to 50% of cabbage; and 75 to 80% of tomato, while they were more in the range of 100% to 200% for vegetables (Moustier, Vagneron, & Bui Thi, 2004). For the others analyzed cities UPA´s contribution to food prices has been estimated in terms of saved costs on food expenditures and direct income from sales, like in Accra, where in 2000, (Armar-Klemesu & Maxwell, 2000) estimated that the annually saved costs varied from 1 to 5% of the overall food expenditures (up to a maximum of 10%), with higher values in the lower wealth classes. For Nairobi, only qualitative data were found stemming from usual households surveys, in which urban and peri-urban farmers affirmed that UPA´s practices enable them to save some money and thus securing some extra to be spent on other goods, such as school fees, better health care (Danso, Keraita, & Afrane, 2002).

The sustainable development criterion "inclusion of marginalized groups" (e.g. the aged without a pension, unemployed youth, people with disabilities, those afflicted by HIV/AIDS, refugees, female-headed households, etc.) also reported a value equal to 0 for all cities. Findings from the case study research approach indicate that the gender ratio in open-space farming in various African cities varies greatly: more women (80%) than men (20%) are involved in aquaculture (Cofie et al, 2008). Male farmers usually engage in intensive exotic vegetable cultivation, which is deemed more profitable (Cofie, van Veenhuizen, & Drechsel, 2005), while women are found in vegetable traditional cultivations and related market activities (Cofie, van Veenhuizen, & Drechsel, 2005). Other data stemming from a cross-cities survey involving 1.000 households in different African countries, conducted by IWMI and RUAF in 2006, showed that both men and women are equally engaged in backyard cultivation depending on the type of crop or livestock (Cofie et al, 2008). For Latin American cities data available indicate, for example in Rosario, two-thirds of gardeners have been estimated to be women (World Bank, 2013b). For Cuba, in 2013, the FAO reported between 300.000 and 40.000 persons employed in urban agriculture at the national level (FAO, 2013b) and of these, an estimated 167.000 were women, and 40.000 were retirees (FAO, 2013b). Still from the same study, specifically for the city of Havana estimates reported 15.000 individuals working in urban agriculture, and out of these, 3.770 (25.1%) were women and 7.840 (52.3%) were 60 years of age or older (FAO, 2013b).

Moving to the climate change adaptation criteria, the criterion "use of wastewater for irrigation" displays positive values for Lima, Accra, Nairobi, Kampala, Havana and Hanoi. (Lydecker & Drechsel, 2010) estimated that vegetable farmers, in Accra, used 11.250 m^3 of irrigation water per day and that most of this water was urban gray water, raw or mixed with stream or river water.. For Nairobi, a research by indicated that 3.700 farmers practiced irrigation and that 36% of them use wastewater (Hide & Kimani, 2000). Interesting findings have been also identified from studies conducted in Lima. According to them, in 2006, in the city there was a total of 12.680ha in peri-urban areas, and a total of 985ha of urban agricultural and green areas under wastewater irrigation (Castro et al, 2010). While, 2010 estimates accounted for around 94% of crops in peri-urban districts irrigated either with raw sewage or with river water in the city (Castro et al, 2010). A more recent urban water management study calculated that by re-using slightly more than half of its treated wastewater, Lima could irrigate parks and green areas corresponding to 28.000ha and some 10.800ha of farmland, thus helping to increase yields and the quality of produces (FAO, 2014). Findings for Hanoi forecasted that the usage of wastewater for irrigation could have the potential not only to generate 200–300% and 10–20% short-term financial advantages in rice and fish production, respectively, but it also could improve soil nutrients and fertility (Thu, 2001). Notably, among the reviewed cities, only Kesbewa has a negative value on this criterion due to the lack of quantitative reliable data at the city-level.

The criterion "incidences of floods and erosion" displayed similar values in the reviewed cities. A value higher than 0 for Accra, Nairobi, Lima and Havana has been reported, while only Kesbewa has a negative value. It is important to stress that notwithstanding the values obtained from the PROMETHEE II analysis, no significant quantitative data have been found through the qualitative content analysis and case study research design strongly supporting the claims of UPA´s contribution to reduce the impacts of floods and erosion. For Nairobi and Accra only qualitative claims have been identified about the contribution of UPA to flood reduction capabilities by extending the time lag between floods and storm runoff (FAO, 2007). Similarly, for Kampala studies indicated that due to the flood-prone characteristic of the city (UN-HABITAT, 2011b), some farmers have started to opt for rooftop rainwater harvesting to helps arresting surface water runoff, thereby reducing soil erosion and flooding (Sabiiti et al, 2014). However, these opportunities have not been fully exploited and precise quantitative figures are not available. In Kesbewa the outcomes of a project´ assessment focusing on restoration of paddy land, highlighted that the well management and preservation of lower paddy lands could significantly reduce the impacts of higher rainfall by keeping low lying zones free from construction so that floods have less impact, runoff is reduced, and excess water is stored and infiltrated. By computing estimated according to different scenarios, the project research team calculated that with the actual land use, in Kesbewa, the average run-off coefficient is 0.64 for the urban watershed (Dubbeling, 2014). Envisioning a future land use with an increase in green area in the total area, the run-off coefficient would reach a value of 0.49, which implies approximately a 20% decrease of water run-off compared to present value (Dubbeling, 2014). This reduction in run-off would cause a similar reduction in the risk of urban flooding, which would significantly improve the situation of the urban population (Dubbeling, 2014). Likewise, for Rosario, building upon historical rainfall data, a research team estimated that even a small increase of green areas in urban systems would reduce significantly the risk of flooding, as a 5% reduction in the run-off coefficient would cause a probability reduction of 30% for urban flood risks (Piacentini et al, 2015).

The criterion "reduction of the urban heat island effect" present value equal to 0 for all cities. From the application of the multi-method research design, some estimates have been found for Rosario and Kesbewa. Rosario´s green urban showed that average temperatures in the urban garden parks or in streets/squares with a large tree vegetation were lower than in the central area by around 5°C (Dubbeling, 2014: 13)[67]. In Kesbewa, within 9-months timeframe of a project, in a limited study average temperatures were assessed and found significantly higher for highly built-up urban commercial, residential and industrial land uses (urban region), while lower for open spaces with more vegetation cover and land uses with home gardens (UPA and low density residential areas with home gardens (RUAF, CDKN and UN-HABITAT, 2014). The air temperature recorded for UPA (including forestry) regions was 0.70°C to 1.10°C lower than in built-up urban area, this also reflected in the inside temperature values of the low-density residential area without home gardens (control group) which were always higher than inside temperatures in the low-

[67] Temperatures and measurements were recorded during the months of September 2013 to January 2014

density residential area with home gardens regions (sample group) throughout the study period (RUAF, CDKN and UN-HABITAT, 2014: 27).

Moving to climate change mitigation criteria, outstandingly, from the PROMETHE II analysis it emerged that for these criteria there is either no preference between the cities with values equal to 0 or the values signal negative preference flows values with the only exception of Rosario. This is because Rosario has been the only city for which targeted studies have been conducted with respect to UPA´s possible impacts in the reduction of GHG emissions with respect to food miles of specific UPA´s produces. In 2015, the total annual volume of lettuce transported to the Greater Rosario Region was 40.000 tons per year, to which UPA´s production contributed about 10% while distant production regions 90% (Piacentini et al, 2015). On the basis of these estimated (Piacentini et al, 2015) calculated the possible reduction of CO_2 emissions if urban production would be increased, replacing distant production. They calculated that the amount of CO_2equivalent would decrease equaling the annual GHG emission associated with 757 Argentinian (Piacentini et al., 2015:49). Similar assessments have been conducted for potatoes that are mainly imported from a region located about 630 km from Rosario transported by truck, usually with a capacity of 20 tons (Piacentini et al, 2015). It has been calculated that in order to supply all the potatoes needed to feed the Rosario inhabitants, such transport represents a CO_2 output of 3.350 tons per year (Piacentini et al, 2015). If this food were to be produced in the urban and peri-urban areas of Rosario (located at about 30 km) CO_2 emissions related to food transports would be reduced by 97% per year (Piacentini et al, 2015). Additional estimates have been also produced for squash/pumpkin and string beans. The first are imported from the Ceres region about 200 km from Rosario, while the beans are produced mainly in the horticultural area of Great Buenos Aires about 300 km from Rosario (Piacentini et al, 2015). If they were produced locally, there would be a reduction of 92.5% in CO_2 emissions per year for squash/pumpkins, and about 95% per year while for string beans (Piacentini et al, 2015: 14).

Some figures are also available for the city of Accra. Most perishable vegetables and some fruits consumed in the city come from peri-urban areas, while others, such as onions and tomatoes are transported from extremely long distance (World Bank, 2013b) on average food items in the shops travel 3.700km (by air) (Drechsel et al., 2006a; World Bank, 2013b). However, these estimates appear to be the only available one. A World Bank´s report of 2013 indicates that no further quantitative data have been so far produced to corroborate the GHG reduction potential of UPA practices in Accra. Other data were found for the city of Kesbewa. Although, also framed within specific projects' objectives, a 2012 study highlighted that the majority of the food items sold in Kesbewa are transported from distant places to the city: the average distance travelled by one ton of food item was estimated at 236 km (RUAF, 2014). At the time of the project, 6260m^2 of home gardens were cultivated (0.59%), while the total land area available in Kesbewa Urban Council was 1,063,248m^2 (RUAF, CDKN and UN-HABITAT, 2014). Thus, it was calculated that if all available home gardens were cultivated[68] the total production would be 484.0 tons, providing 15% of current city´s need of gourd, cucumber, eggplants, okra, chili, and capsicum, and reducing food miles by 128.717km[69] (RUAF, CDKN and UN-HABITAT, 2014). Consequently production of these vegetables could double and reach 30% of total urban food demand, resulting in emission savings up to 148.2 tons CO_2 eq./year (RUAF, CDKN and UN-HABITAT, 2014). Some figures were also found for Hanoi, for which estimates reported that about 44% of the citys food requirements are met from domestic production within the city borders, while there is a remaining 56% of food that comes from other provinces. This amount equals to more than 600.000 tons of food meaning that approximately 329 trucks of food have to enter the city every day (assuming each truckload carries 5 tons) thus contributing to GHG emissions (Phuang et al., 2004). Nevertheless, no more precise estimated were found about possible reduction. The available data found for Cuba do not display precise quantitative estimates for Havana, and also mainly referred to the country´s measures implemented to face the oil crisis. The country turned to solar and wind energy to meet its rural electrification and farm needs, thus decreasing its overall GHG emissions and tapped its energy potential by introducing biogas digesters to decompose animal wastes to generate energy (Hiranandani, 2010).

Looking at the criteria "use of chemical fertilizers/pesticides" and "landfill volume", the presented case studies reported some interesting though scattered data. In Rosario the use of vermiculture for both the processing of organic waste and the production of bio fertilizers and animal protein has proved to be successful (Spiaggi, 2005). A project was implemented offering local courses on vermiculture, which

[68] Also assuming that production levels of home gardens can be increased if space is more intensively used and crop management is improved (RUAF, 2014b).

[69] Because the average use of the 1.25 and 3 ton truck was assumed to be 0.125 liter per km, this would mean a reduction in fuel use of 16 089 liter diesel and in 74.1 tons CO2 eq/year (RUAF, 2014b).

resulted in a total of about 6 tons of organic waste annually processed in 20 production modules on the two community farms, rendering about 2.6 tons of vermicompost (Spiaggi, 2005). From a social and environmental perspective, considering the fact that the municipal waste-collection system in many neighborhoods in the city does not function, the vermicompost contribute to mitigate a significant urban challenge (Spiaggi, 2005). For Nairobi, studied were identified assessing the potential of organic waste´s composting. The results showed that it could help in reducing the mining of finite mineral resources (such as P) and energy expended to produce artificial fertilizer (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011: 5). Prain et al., (2010) estimated that in the city every day, circa 2.223 tons each of nitrogen (N) and phosphorus (P) and circa 3.700 tons of potassium (K) could be generated from the city's estimated 635.000 tons of waste (de Zeeuw, Van Veenhuizen , & Dubbeling, 2011: 5). Nevertheless, despite the concentration of nutrients in manure and organic waste (70% of Nairobi's solid waste is biodegradable and potentially useful) the recycling systems are still imperfect and large amounts of waste that could be reuse are simply dumped. For example, estimates for 2003–2004 showed that very little of the estimated 2.000 tons each of nitrogen (N) and phosphorus (P) and 3.700 tons of potassium (K) were used due to the lack of knowledge many farmers, who still use highly pest management, and toxic, obsolete pesticide without protection (FAO, 2012b). Overall, in Nairobi, less than 1% of organic solid waste generated is reused (Prain, Karanja, & Lee-Smith, 2010). Similarly in Accra, still a considerable amount of farmers applied chemical pesticides (De Bon, Wardekker, & van der Sluijs, 2010). The World Bank estimated that in the city, 46% of producers used chemical fertilizers, 24% animal manure, and only 18% compost on crops along with additional inputs such as seeds (81%), pesticides (51%)(World Bank, 2013b). In Accra 255.000 to 366.000 tons of organic waste are effectively available annually for composting, and if it were recycled, biodegradable solid waste could yield 35.000 tons of compost a year (FAO, 2012b). The nutrient content of this 35.000 tons of waste in Accra alone is estimated at 3.500 to 5.300 tons per year of nitrogen, 1.700 to 2.600 tons per year of phosphorus and 760 – 1.100 tons per year of potassium, amounts that could easily cover the entire nutrient demand of urban and peri-urban farming (Drechsel & Dongus, 2010: 2). However, this potential remains unexploited due lower costs of chemical fertilizers, and to lack of knowledge. Kampala also presents great opportunities to address solid waste management and nutrient recycling challenges. A recent study from (Prain, Karanja, & Lee-Smith, 2010) reported of pig-raisers sampled from six parishes across the peri-urban to urban continuum in Kampala, found that the 144 pig-raisers recycled nearly 70 tons of organic wastes per week. These wastes account for 1.3% of Kampala's estimated weekly generation of 5.535 tons of organic waste (Prain, Karanja, & Lee-Smith, 2010: 30). In addition to its use as animal feed, organic municipal waste is also used in Kampala as a soil amendment in backyard gardens and for cooking fuel (Prain, Karanja, & Lee-Smith, 2010). UPA could have, therefore, an important, positive contribution to make in reducing the solid waste stream in the city, which as for the others mentioned cities still have to be exploited. In Kesbewa, a home gardening project started using the 60.200 kg of urban organic compost, resulting in a reduction of municipal solid waste that would otherwise have been transported to landfill. The households involved were able to reduce the use of external fertilizers by 56.3% also saving together approximately Rs. 175.560 over the project period (9-months period) (Dubbeling, 2014: 10). In Havana, turning waste into useful materials has been a widespread activity involving not only urban and peri-urban farmers but also the general population, as the uptake of UPA in Cuba has resulted in the near elimination of local refuse dumps for household waste (Hoornweg & Munro-Faure, 2008). Most of the agriculture in the city is fully organic since law prohibits the use of agrochemicals in urban gardens and it is also impractical, given the limited quantities available. Livestock production has a prominent place in the preparation of organic fertilizers such as compost and/or worm humus on the farms, supplying 20 to 60% of fertilization needs (Hoornweg & Munro-Faure, 2008). Because a reliable supply of soil nutrients is essential for improving garden substrate and maintaining high yields, UPA´s programs in Havana have also promoted production of compost, green manure, vermicompost, bio-fertilizer and liquid fertilizers, links gardeners to sources of manure (FAO, 2014; Hiranandani, 2010). Data for Hanoi indicate that despite the fact that some 60% of total household waste is collected, less than 5% of it undergoes treatment in the Hanoi Urban Environment Company plant (URENCO) resulting in significant amounts still dumped (Midmore & Jansen, 2003).

Finally, with respect to the climate change mitigation criterion "carbon sequestration" it is evident that no quantitative data are available for the reviewed nine case studies. Current literature does not provide estimates that could be used to assess UPA´s contribution and impacts on the ground, as it mainly refer to qualitative data or discursive analyses.

Reflections & Conclusion

8 The status quo: UPA as climate-smart strategy

8.1 What has emerged from the multi-methods research approach

While, theoretically, many assumptions have been made about UPA´s potential as climate-smart agricultural strategy, key challenges remain about its triple-wins impacts on the ground. This research through the application of a multi-methods research design provided a first grounded comparative analysis of urban and peri-urban farming practices in nine cities located in different low- and middle-income countries: bringing to light an up-to-date picture of UPA´s current triple-wins impacts and consequently revealing how UPA´ potential as climate smart strategy is yet to be fully exploited and practically not as advanced as claimed in the literature. The applied analyses also revealed new insights about barriers and trade-offs hindering the effective uptake of UPA practices as climate smart agricultural strategies in the analyzed countries.

The PROMETHEE II results highlighted how the economic, social and environmental benefits of UPA to individuals, households, and communities underpin its practice. UPA´s role in livelihood enhancement is well documented, especially its positive influence on sustainable developments aspects (e.g. Maxwell, Levin, Armar-Klemesu, Ruel, Morris, & Ahiadeke, 2000; Cofie, van Veenhuizen, & Drechsel, 2003; Cofie, van Veenhuizen, & Drechsel, 2005; FAO, 2007). In each of the analyzed urban areas, the most accounted motivation for practicing UPA, is indeed its concrete contribution to household food security (e.g. Cofie, van Veenhuizen, & Drechsel, 2003; Drechsel & Dongus, 2010; Drechsel et al, 2006) and to the generation of employment especially for the urban poor, living in cities where there is a mismatch between the labor force and employment opportunities (e.g. (World Bank, 2013b; FAO, 2007; Cofie et al, 2008). However, the PROMETHEE II analysis also pointed out how UPA´s contribution to others sustainable development aspects, such as "reduction of food prices", "improved diets and nutrition" and "inclusion of marginalized groups into economic activities" is rather limited in the nine analyzed cities. It is important to stress that the more limited influence of the above-mentioned criteria seems to be mainly due to a lack of adequate data and to analytical difficulties due to diversified analytical metrics applied. For example, for the criterion "reduction of food prices" some studies use price differentials between the farm and the final consumers (e.g. Moustier, 2001), while others assess saved costs on food expenditures and direct income from sales (e.g. Armar-Klemesu & Maxwell, 2000). Similarly, the interaction between UPA and "improved diets and nutrition" is not always so straightforward. The majority of studies relies upon households' surveys, and hence builds upon subjective answers of farmers and non-farmers concern with their food situation. Only few quantitative statistical estimates are available which however also present a limited focus providing data for cities' slums and/or districts and/or for specific segments of the urban populations (i.e. children younger than five years) (e.g. Cofie, van Veenhuizen, & Drechsel, 2003); therefore lacking a full urban-level perspective necessary for integrated assessments and cities cross-comparisons. Similar conclusions can be derived for UPA´s influence on the "inclusion of marginalized groups into economic activities" (i.e. the aged without a pensions, unemployed youth, people with disabilities, female-headed households etc.). UPA practices are often indicated as successful social inclusive strategies, providing marginalized people with an opportunity to feed their families and raise their income, while enhancing their self-esteem and management capacities (e.g. Moustier, 2001). However, the results showed that available data mainly account for estimates of women engaged in UPA activities (the higher percentages of women´s engagement can be often attributed to women low social status (FAO, 2007)) without taking into consideration differentiation of gender and age. No analyses assess the differential impacts of UPA on women, men and youth as part of the farm household members, and consequently there is no clear indication on whether UPA is really significant in providing higher social inclusions in urban contexts for the whole community.

From the outcomes of PROMETHEE II also emerged that UPA´s direct contribution to mitigation and adaptation issues is yet to be fully analyzed, with only limited data directly assessing these aspects (e.g. de Zeeuw, Van Veenhuizen , & Dubbeling, 2011; Piacentini et al, 2015; World Bank, 2013b; RUAF, CDKN and UN-HABITAT, 2014). In terms of climate change adaptation, the literature refers to UPA practices as effective strategies that can help to reduce flooding and landslides, contribute to reduce the UHI effect, by preventing construction on risk-prone land, maintain/increase green urban areas thus reducing surface water run-off and hence enhancing water storage (e.g. Dubbeling, Caton Campbell, Hoekstra, & van Veenhuizen, 2009; de Zeeuw, Van Veenhuizen , & Dubbeling, 2011). From the PROMETHEE II results, however, one can observe that all the nine case studies perform rather poorly with respect to the climate change adaptation criteria. What emerged is that when implementing UPA practices on the ground, climate change adaptation issues are not directly approached, but rather embedded within environmental and health-risks operational frameworks. This also explains, for example, the higher availability of analyses, especially for African cities for the adaptation criterion "use of wastewater for irrigation". Centered around sanitation challenges, water pollution and food safety, the criterion is of utmost importance as urban and peri-urban farmers in search of irrigation water find it almost impossible to source unpolluted surface water or properly treated wastewater (e.g. Cornish & Kielen, 2004). Likewise data and examples about UPA´s potential to "reduce incidences of floods/erosions" and the "UHI effect" are generally couched as environmental concerns, not as potential climate change adaptation measures. They are mainly assessed against targeted and short-term projects´ objectives and/or scenarios analyses, in the context of household and community responses to impacts such as windstorms, heavy rainfall and flooding (e.g. Dubbeling, 2014; Piacentini et al, 2015).

Likewise, UPA´s contribution to improve the ecological systems, the microclimate, and biodiversity and overall the quality of life in urban and peri-urban areas does not appear to be so significant as suggested in the literature. The PROMETHEE II outcomes only partially substantiated the claims that UPA could actually contribute to GHG emissions reduction, clearly highlighting that UPA´s potential still have to be concretely assessed and that where already existing UPA´s contribution is rather small, targeting single food produces and/or single neighbors/districts (e.g. Phuong, Ali, Lan, & Ha, 2004; RUAF, CDKN and UN-HABITAT, 2014; Piacentini et al, 2015). For the carbon sequestration criterion, the outcomes were even more limited as the reviewed literature simply illustrates that different urban surfaces with trees and ornamental plants have the potential to sequester organic carbon of up to 140 g C m-2/y-1 (Townsemd-Small & Czimczik, 2010) while no quantitative estimates have been identified and thus included in the PROMETHEE II analysis for any of the analyzed cities. On the contrary, the criteria "reduction of landfill" and "reduction of polluting chemical fertilizers/pesticides" present a mixed picture. Although, UPA´s potential to reduce the difficulties of disposing solid wastes, and to replace the use of expensive and potentially harmful substances with organic nutrient recycling is largely discussed and in some real instances assessed (FAO, 2007; Hiranandani, 2010) in the nine analyzed cities, the current status quo exemplified a fragmented situation with some cities performing rather well, while in some others UPA`s potential is completely unexploited. In Havana, for example chemical fertilizers have been completely banned from UPA practices, while in Hanoi urban and peri-urban farmers are still making significant use of these substances due to both a lack of knowledge about environmental and health risks and to their more affordable costs (FAO, 2014; Hiranandani, 2010). A similar fragmented picture has been derived for the criterion "reduction of landfill", since current data and analyses do not provide a sufficient knowledge base to concretely understand UPA's impacts and thus to clearly measure UPA`s contribution in addressing urban waste disposal challenges.

What also emerged from the multi-methods research analyses is that despite the already acknowledged barriers in the literature (i.e. perception of health and environmental risks, the real or perceived concerns related to contamination by wastewater recycling and utilization of manure, lack of institutional legitimacy) additional factors play a role in the successful implementation of UPA practices, including limited operational level, no proper institutional engagement and a clear understanding of benefits and trade-offs of mitigation, adaptation and sustainable development aspects. Starting with the operational level, the nine case studies raise serious doubts as to the extent to which current urban and peri-urban farming practices are operating at a scale sufficiently large to allow them to act as climate smart strategies. Current data and assessments are strongly linked to micro or at best meso urban social, economic, political, ecological and spatial analytical levels. Most sources draw from households' surveys building upon a narrow population sample, consisting either of limited quantitative data or at worst of merely descriptive assessments, resulting in extremely context-specific analyses. Furthermore, these analyses are strongly driven and thus shaped by national and international funding and related projects' objectives. National macro-level analyses of UPA practices integrated into local/regional or even national contexts, allowing cities comparisons remain a major knowledge gap. There is the need for more systematic research on UPA´s triple-wins impacts using standardized indicators and measuring methods to process and share data that can help to scale out and to scale up successful UPA practices. More specific data and information need to be developed: for example on the actual health impacts of UPA practices, and on the costs and benefits of agricultural produces, which are often sold informally. At the city level, the aggregate income and employment effects of UPA have to be assessed as well as the indirect costs and benefits generated by UPA for the city, such as the positive and negative effects on the social, health and environmental situation of the urban population. Broadly speaking, because of its local focus, the development of UPA is strongly influenced by the dynamics of the urban social, economic, political, ecological, and spatial systems with which it is connected. Future studies will have to systematize data collection and analytical methods and clearly consider and evaluate the interactions of UPA with other urban activities so to bring the analytical work to a level that accounts for city/regional-wide impacts framed within a climate-smart agriculture framework.

In addition to the generation of more specific data and information, the successful implementation of UPA practices also clearly calls for suitable policy environments. First of all, urban planners and decision makers cannot be expected to base their policy recommendations on what can be currently defined as anecdotal evidence. Secondly, considering UPA strategies are still largely internationally driven, local/regional governmental representatives are still too often engaged only towards the final implementation phases (apart from the exceptions of Havana and Rosario and most recently Kesbewa). Although, this lack of authorities engagement (already resulting in a lack of institutional legitimacy) is not completely hindering the implementation of UPA practices, it does reinforce the misleading perception among policy-makers that UPA does not bring along significant economic benefits and that farming practices are rural rather than urban activities. Thus, in many cities local/regional governments not only do not actively promote UPA, but also act against it emanating restrictive and discriminative urban policies. City authorities do not see the incentives to integrate it into urban development planning processes and this in turn creates what can be defined as a "land challenge". In most cities in low and middle-income countries UPA face very stiff competition from other urban land uses (residential, institutional, commercial and industrial development, among others) and thus the areas that can be used for agricultural production are most often unsuitable, making UPA practices not sustainable in the long-term. Even though a major function of UPA is and will always be food supply and income generation in cities, local/regional and even national authorities need to be actively engaged in order to enable a better understanding and recognition that these farming practices can also play a key role in promoting economic and social welfare as well as environmental and biodiversity management, enhancing the city´s resilience. Policy initiatives directed at UPA need to include the provision of access to municipal land, farmers´ trainings, technical assistance, investment, and marketing support for agricultural production. There is the need to move beyond the conceptualization of urban and peri-urban farming practices as local and short-term responses to social crises (i.e. local governments concern about growing food insecurity focusing on the sustainable development dimension of UPA) making UPA an effective development and climate change urban strategy. This will also support the institutionalization of UPA practices as an integral part of the urban socio-economic and ecological systems. Local/regional institutions and policies will have to be reformed to support the multifunctional potential of UPA social and eco-systems services. Mainstreaming UPA practices into the appropriate governance structures by involving all relevant stakeholders in the planning, implementation and monitoring phases can make cities places of innovation and efficiency, having the potential to diminish the causes of climate change (mitigation), effectively protecting themselves from its impacts (adaptation) and further driving sustainable development processes.

Due to the complexity of the issues at stake and the limited resources available to cities' governments, instead of advocating for a full-fledge revision of existing tools and policy mechanisms, the recommendation here is to re-think and reflect on how to make best use of existing policies and frameworks. To make some practical examples, entry points to frame UPA practices not only as contributing to sustainable development aspects, but also to act as an effective mitigation and adaptation strategy can be represented by the revision of existing urban land use plans, from its direct integration into the National Adaptation Programmes of Action (NAPA) and into the most recent climate change actions represented by the Nationally Appropriate Mitigation Actions (NAMAs). Successful examples in this direction are the Adaptation of African Agriculture[70](AAA) and the Milan Urban Food Policy Pact.[71] Launched at the Agriculture and Food Security Action Event during the UN Climate Change Conference in Marrakech (COP22). These initiatives are designed to assist small-scale farmers in building their adaptive capacities, to help urban citizens in dealing with the impacts of climate change and to support countries in fulfilling their sustainable development objectives.

[70] http://www.aaainitiative.org/initiative
[71] http://www.milanurbanfoodpolicypact.org/

8.2 Conclusive remarks

At the end of the 20th century, the size of modern cities in terms of numbers as well as physical scale is unprecedented. In 2008, the world's urban population outnumbered its rural population for the first time in history (FAO, 2009; UN-HABITAT, 2010). Currently, approximately one-third of the world's population is living in slums and informal settlements (FAO, 2009). This unprecedented urban growth couple with a changing climate is exacerbating negative environmental and social issues. The urbanization process appears to go hand in hand with growing urban poverty and food insecurity. FAO estimates that negative climate change impacts on agricultural production resulted in higher food prices. The number of chronically hungry people in the world rose by at least 100 million in the past years to currently reach over 1 billion people (FAO, 2014). It is gradually apparent that effective strategies in urban contexts are necessary not only to diversify food sources, but also to mitigate and adapt to climate change maintaining sustainable resource management. The triple-wins concept embedded in climate-smart agricultural approaches represents a decisive solutions, which in urban contexts has been exemplified into a renew attention towards urban and peri-urban agricultural practices.

As discussed in this research, UPA is not a new phenomenon; however, its contextualization as climate-smart agricultural strategy is rather recent and is presenting an extremely diversified picture, from which it is still difficult to evaluate its operative triple-wins impacts on the ground. Currently only limited quantitative data are available for conducting effective evaluations and comparisons of aggregate triple-wins UPA impacts in different cities worldwide. In response to this analytical gap, this research applied a multi-methods research design aiming at better understanding and evaluating UPA´s effectiveness as a climate-smart strategy by assessing its on the ground triple-wins impacts, in cities located in different low and middle-income countries. The decision of applying a multi-methods research design was taken considering that multiple methods – consisting of the qualitative content analysis, a case studies research method, and the multicriteria decision analysis PROMETHEE II method - can provide a much richer picture of the phenomena under study, rendering the analytical evidence stemming from them more compelling and robust, as well as enabling to overcome existing analytical challenges which are unavoidable when working with secondary source data. A practical example is the analytical challenge encountered due to the lack of a universally accepted definition as to what constitutes UPA and as where the peri-urban area ends and the rural hinterland begins. In addition, the evaluation through secondary source data has been also further complicated by the experienced differences in methodologies, indicators and units of analysis existing in the UPA´s literature. Current studies present a vast array of data and analytical methods varying widely not only among cities but also within the same urban contexts compounding the uncertainty, and if not adequately tackled limiting cross-cities comparative analyses and effective evaluations of UPA´s triple-wins impacts.

From the implementation of the various analytical methods a number of interesting observations and new insights were derived. First of all, this analysis found only fractional evidence supporting the theoretical assumptions advocating UPA´s efficiency as climate-smart strategy in urban contexts of low and middle-income countries. The results reflect how UPA is clearly a complex concept not only presenting a variety of definitions at the theoretical level, but also a variety of applications on the ground. The developed evidence indicates that UPA is already contributing and having positive impacts on sustainable development aspects, such as "increase food security" and "income/employment generation". Outcomes also point out that UPA has the potential to be an effective climate-smart agricultural strategy, even though existing data and studies do not provide yet enough quantitative evidence to substantiate current UPA´s on-the-ground contribution on climate change adaptation and mitigation issues. Accordingly, this research shed new light about the existing information/data gap, consisting of a lack of quantitative figures providing conclusive evidence of how these farming practices are faring under intensified drivers of change, and the extent to which they represent effective triple-wins strategies, particularly, in low and middle-income countries where their potential as climate-smart strategies is higher. Existing data and analyses are confined to micro or meso level, focusing on determined agricultural produces, households' surveys, urban neighbors and/or districts. There are too little quantitative data hitherto available on the tangible aggregate economic, environmental as well as social contribution of urban and peri-urban farming practices in low and middle-income countries. The research outcomes also highlight a significant lack of proper stakeholder engagement processes combined with a lack of understanding from cities authorities about the economic, social and environmental opportunities that UPA can bring along. These result in the persistence of outdated modernist attitudes, restrictive laws and regulations, which even though they seem not impede the engagement in UPA activities at the local level, they do hinder the broader uptake and effective mainstreaming of UPA practices into local and national urban planning, sustainable development and climate change policies.

Taken as a whole the outcomes deriving from the application of a multi-methods research approach reinforce the initial assumption that much literature has been published on the topic, reflecting how the concept of climate smart agriculture enjoys the outspoken support of international development agencies. While major challenges still remain in terms of assessing UPA´s on the ground triple-wins impacts since the majority of existing researches lack empirical evidence and only few studies have generated reliable quantitative data, which however are not sufficient for a fully fledged triple-wins assessment. Indeed, what does immediately stand out from this analysis is that none of the assessed cities performed extremely well. Quantitative evidence is fragmented and has been found mainly with respect to sustainable development criteria, while little or no data exist for the climate change mitigation and adaptation criteria.

Notwithstanding, it is important to stress and to clearly communicate that the outcomes of this research should not be interpreted in the narrowest sense of urban and peri-urban farming practices being not suitable climate-smart strategies, but rather as generating additional data on the topic. The analytical results provide a better understanding of the status quo in terms of existing knowledge gaps and operational challenges. They thus contribute to the ongoing debate about UPA´s success as climate-smart agricultural strategy and offer a starting point for future researches/analyses thanks to the new insights derived from the cross-cities comparative assessment. Indeed, though, the reviewed nine case studies cannot determine the prevalence of a phenomenon, they are useful tools to explain the mechanisms by which a phenomenon exists, persists and can be changed, in this case UPA´s on the ground effectiveness as climate-smart agricultural strategy.

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Appendixes

9 Appendix I

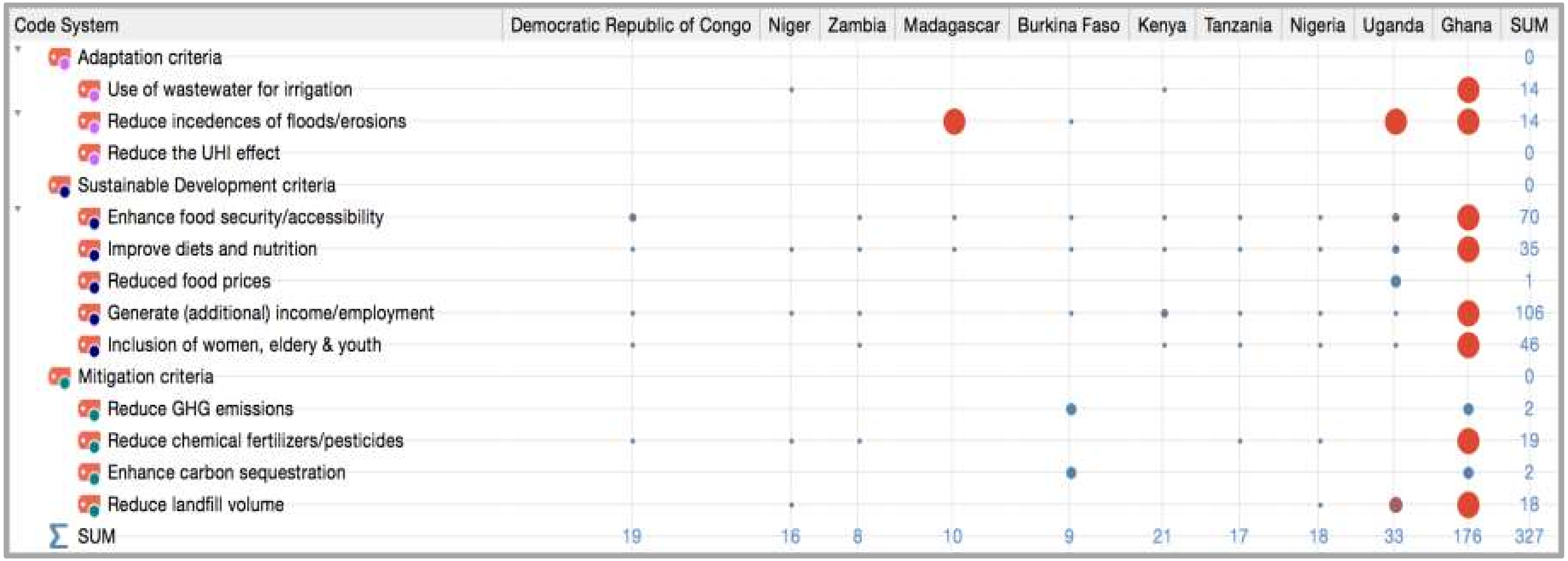
Table A1.1: Asian cross-countries comparison

Code System	Thailand	Cambodia	Vietnam	India	Nepal	Philippines	Kesbewa, SriLanka	SUM
Adaptation criteria							●	2
Use of wastewater for irrigation			●		●		●	7
Reduce incedences of floods/erosions		●	●				●	13
Reduce the UHI effect							●	9
Sustainable Development criteria							●	2
Enhance food security/accessibility	●	●	●	●	●	●	●	51
Improve diets and nutrition	●	●	●	●		●	●	11
Reduced food prices			●				●	5
Generate (additional) income/employment	●	●	●	●	●	●	●	54
Inclusion of women, eldery & youth	●		●	●	●		●	15
Mitigation criteria							●	1
Reduce GHG emissions		●	●		●		●	17
Reduce chemical fertilizers/pesticides	●	●	●	●	●		●	18
Enhance carbon sequestration								0
Reduce landfill volume	●		●	●			●	12
SUM	13	26	50	26	20	3	79	217

Table A1.2: Latin America cross-countries comparison

Code System	Bolivia	Mexico	Peru	Cuba	Argentina	Brazil	SUM
Adaptation criteria							0
Use of wastewater for irrigation							9
Reduce incedences of floods/erosions							2
Reduce the UHI effect							2
Sustainable Development criteria							0
Enhance food security/accessibility							39
Improve diets and nutrition							11
Reduced food prices							1
Generate (additional) income/employment							25
Inclusion of women, eldery & youth							8
Mitigation criteria							0
Reduce GHG emissions							8
Reduce chemical fertilizers/pesticides							10
Enhance carbon sequestration							1
Reduce landfill volume							7
SUM	3	0	7	98	15	0	123

Table A1.3: African cross-countries comparison



Code System	Democratic Republic of Congo	Niger	Zambia	Madagascar	Burkina Faso	Kenya	Tanzania	Nigeria	Uganda	Ghana	SUM
Adaptation criteria											0
Use of wastewater for irrigation											14
Reduce incedences of floods/erosions											14
Reduce the UHI effect											0
Sustainable Development criteria											0
Enhance food security/accessibility											70
Improve diets and nutrition											35
Reduced food prices											1
Generate (additional) income/employment											106
Inclusion of women, eldery & youth											46
Mitigation criteria											0
Reduce GHG emissions											2
Reduce chemical fertilizers/pesticides											19
Enhance carbon sequestration											2
Reduce landfill volume											18
SUM	19	16	8	10	9	21	17	18	33	176	327

10 Appendix II

Table A2.1: FREQUENCIES Accra (Ghana)

	Frequency	Percent	Percent (valid)	Percent (cum.)
Enhance food security	7	16,7	17,9	17,9
Generate income/employment	21	50,0	53,8	71,8
Inclusion of marginalized groups	3	7,1	7,7	79,5
Undefined	8	19,0	20,5	100,0
TOTAL (valid)	39	92,9	100,0	
MISSING: System	3	7,1		
TOTAL	42	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Incidences of floods/erosions	4	9,5	21,1	21,1
Use of wastewater for irrigation	11	26,2	57,9	78,9
Undefined	4	9,5	21,1	100,0
TOTAL (valid)	19	45,2	100,0	
MISSING: System	23	54,8		
TOTAL	42	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Use of chemical fertilizers/pesticides	9	21,4	36,0	36,0
Reduce GHG emissions	4	9,5	16,0	52,0
Reduce landfill volume	6	14,3	24,0	76,0
Undefined	6	14,3	24,0	100,0
TOTAL (valid)	25	59,5	100,0	
MISSING: System	17	40,5		
TOTAL	42	100,0		

Table A2.2: FREQUENCIES, Nairobi (Kenya)

	Frequency	Percent	Percent (valid)	Percent (cum.)
Enhance food security	6	17,1	17,1	17,1
Generate income/employment	21	60,0	60,0	77,1
Inclusion of marginalized groups	2	5,7	5,7	82,9
Undefined	6	17,1	17,1	100,0
TOTAL (valid)	35	100,0	100,0	
MISSING: System	0	0,0		
TOTAL	35	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Incidences of floods/erosions	3	8,6	18,8	18,8
Use of wastewater for irrigation	9	25,7	56,2	75,0
Undefined	4	11,4	25,0	100,0
TOTAL (valid)	16	45,7	100,0	
MISSING: System	19	54,3		
TOTAL	35	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Use of chemical fertilizers/pesticides	6	17,1	28,6	28,6
Reduce GHG emissions	4	11,4	19,0	47,6
Reduce landfill volume	5	14,3	23,8	71,4
Undefined	6	17,1	28,6	100,0
TOTAL (valid)	21	60,0	100,0	
MISSING: System	14	40,0		
TOTAL	35	100,0		

Table A2.3: FREQUENCIES, Kampala (Uganda)

	Frequency	Percent	Percent (valid)	Percent (cum.)
Enhance food security	8	22,2	22,2	22,2
Generate income/employment	18	50,0	50,0	72,2
Inclusion of marginalized groups	3	8,3	8,3	80,6
Undefined	7	19,4	19,4	100,0
TOTAL (valid)	36	100,0	100,0	
MISSING: System	0	0,0		
TOTAL	36	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Incidences of floods/erosions	4	11,1	25,0	25,0
Use of wastewater for irrigation	8	22,2	50,0	75,0
Undefined	4	11,1	25,0	100,0
TOTAL (valid)	16	44,4	100,0	
MISSING: System	20	55,6		
TOTAL	36	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Use of chemical fertilizers/pesticides	6	16,7	26,1	26,1
Reduce GHG emissions	4	11,1	17,4	43,5
Reduce landfill volume	7	19,4	30,4	73,9
Undefined	6	16,7	26,1	100,0
TOTAL (valid)	23	63,9	100,0	
MISSING: System	13	36,1		
TOTAL	36	100,0		

Table A2.4: FREQUENCIES Rosario (Argentina)

	Frequency	Percent	Percent (valid)	Percent (cum.)
Enhance food security	5	20,8	22,7	22,7
Generate income/employment	11	45,8	50,0	72,7
Undefined	6	25,0	27,3	100,0
TOTAL (valid)	22	91,7	100,0	
MISSING: System	2	8,3		
TOTAL	24	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Incidences of floods/erosions	4	16,7	28,6	28,6
Reduce the UHI effect	1	4,2	7,1	35,7
Use of wastewater for irrigation	6	25,0	42,9	78,6
Undefined	3	12,5	21,4	100,0
TOTAL (valid)	14	58,3	100,0	
MISSING: System	10	41,7		
TOTAL	24	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Use of chemical fertilizers/pesticides	4	16,7	25,0	25,0
Reduce GHG emissions	6	25,0	37,5	62,5
Reduce landfill volume	2	8,3	12,5	75,0
Undefined	4	16,7	25,0	100,0
TOTAL (valid)	16	66,7	100,0	
MISSING: System	8	33,3		
TOTAL	24	100,0		

Table A2.5: FREQUENCIES Lima (Peru)

	Frequency	Percent	Percent (valid)	Percent (cum.)
Enhance food security	4	17,4	20,0	20,0
Generate income/employment	10	43,5	50,0	70,0
Undefined	6	26,1	30,0	100,0
TOTAL (valid)	20	87,0	100,0	
MISSING: System	3	13,0		
TOTAL	23	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Incidences of floods/erosions	3	13,0	21,4	21,4
Use of wastewater for irrigation	8	34,8	57,1	78,6
Undefined	3	13,0	21,4	100,0
TOTAL (valid)	14	60,9	100,0	
MISSING: System	9	39,1		
TOTAL	23	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Use of chemical fertilizers/pesticides	4	17,4	28,6	28,6
Reduce GHG emissions	4	17,4	28,6	57,1
Reduce landfill volume	2	8,7	14,3	71,4
Undefined	4	17,4	28,6	100,0
TOTAL (valid)	14	60,9	100,0	
MISSING: System	9	39,1		
TOTAL	23	100,0		

Table A2.6: FREQUENCIES Havana (Cuba)

	Frequency	Percent	Percent (valid)	Percent (cum.)
Enhance food security	7	26,9	28,0	28,0
Generate income/employment	11	42,3	44,0	72,0
Undefined	7	26,9	28,0	100,0
TOTAL (valid)	25	96,2	100,0	
MISSING: System	1	3,8		
TOTAL	26	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Incidences of floods/erosions	3	11,5	23,1	23,1
Use of wastewater for irrigation	7	26,9	53,8	76,9
Undefined	3	11,5	23,1	100,0
TOTAL (valid)	13	50,0	100,0	
MISSING: System	13	50,0		
TOTAL	26	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Use of chemical fertilizers/pesticides	7	26,9	38,9	38,9
Reduce GHG emissions	4	15,4	22,2	61,1
Reduce landfill volume	3	11,5	16,7	77,8
Undefined	4	15,4	22,2	100,0
TOTAL (valid)	18	69,2	100,0	
MISSING: System	8	30,8		
TOTAL	26	100,0		

Table A2.7: FREQUENCIES Kesbewa (Sri Lanka)

	Frequency	Percent	Percent (valid)	Percent (cum.)
Enhance food security	4	14,3	16,7	16,7
Generate income/employment	13	46,4	54,2	70,8
Undefined	7	25,0	29,2	100,0
TOTAL (valid)	24	85,7	100,0	
MISSING: System	4	14,3		
TOTAL	28	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Incidences of floods/erosions	8	28,6	40,0	40,0
Reduce the UHI effect	2	7,1	10,0	50,0
Use of wastewater for irrigation	7	25,0	35,0	85,0
Undefined	3	10,7	15,0	100,0
TOTAL (valid)	20	71,4	100,0	
MISSING: System	8	28,6		
TOTAL	28	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Use of chemical fertilizers/pesticides	4	14,3	20,0	20,0
Reduce GHG emissions	7	25,0	35,0	55,0
Reduce landfill volume	3	10,7	15,0	70,0
Undefined	6	21,4	30,0	100,0
TOTAL (valid)	20	71,4	100,0	
MISSING: System	8	28,6		
TOTAL	28	100,0		

Table A2.8: FREQUENCIES Hanoi (Vietnam)

	Frequency	Percent	Percent (valid)	Percent (cum.)
Enhance food security	8	30,8	32,0	32,0
Generate income/employment	10	38,5	40,0	72,0
Undefined	7	26,9	28,0	100,0
TOTAL (valid)	25	96,2	100,0	
MISSING: System	1	3,8		
TOTAL	26	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Incidences of floods/erosions	4	15,4	26,7	26,7
Use of wastewater for irrigation	8	30,8	53,3	80,0
Undefined	3	11,5	20,0	100,0
TOTAL (valid)	15	57,7	100,0	
MISSING: System	11	42,3		
TOTAL	26	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Use of chemical fertilizers/pesticides	5	19,2	29,4	29,4
Reduce GHG emissions	4	15,4	23,5	52,9
Reduce landfill volume	4	15,4	23,5	76,5
Undefined	4	15,4	23,5	100,0
TOTAL (valid)	17	65,4	100,0	
MISSING: System	9	34,6		
TOTAL	26	100,0		

Table A2.9: FREQUENCIES Phnom Penh (Cambodia)

	Frequency	Percent	Percent (valid)	Percent (cum.)
Enhance food security	6	24,0	26,1	26,1
Generate income/employment	10	40,0	43,5	69,6
Undefined	7	28,0	30,4	100,0
TOTAL (valid)	23	92,0	100,0	
MISSING: System	2	8,0		
TOTAL	25	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Incidences of floods/erosions	5	20,0	35,7	35,7
Use of wastewater for irrigation	6	24,0	42,9	78,6
Undefined	3	12,0	21,4	100,0
TOTAL (valid)	14	56,0	100,0	
MISSING: System	11	44,0		
TOTAL	25	100,0		
	Frequency	**Percent**	**Percent (valid)**	**Percent (cum.)**
Use of chemical fertilizers/pesticides	4	16,0	25,0	25,0
Reduce GHG emissions	5	20,0	31,2	56,2
Reduce landfill volume	3	12,0	18,8	75,0
Undefined	4	16,0	25,0	100,0
TOTAL (valid)	16	64,0	100,0	
MISSING: System	9	36,0		
TOTAL	25	100,0		

11 Appendix III

Table A3.1: 9-point value scale performance matrix

	Food security	Diets & Nutrition	Food prices	Income Employment	Marginalized groups	Wastewater	Floods/Erosions	UHI effects	GHG emissions	Chemical fertilizers/ pesticides	Carbon sequestration	Landfill volume
Rosario	2	1	1	5	1	4	3	1	4	3	1	2
Nairobi	2	1	1	6	1	5	3	1	2	3	1	2
Lima	2	1	1	5	1	5	2	1	3	3	1	2
Kampala	2	1	1	5	1	5	3	1	2	3	1	3
Accra	2	1	1	5	1	5	2	1	2	4	2	3
Hanoi	3	1	1	4	1	5	3	1	2	3	1	2
Phnom Penh	2	1	1	3	1	4	3	1	3	3	1	2
Havana	3	1	1	4	2	5	2	1	2	4	1	2
Kesbewa	2	1	1	5	1	3	4	1	3	2	1	2

Source: own elaboration

Table A3.2: Unicriterion preference flows

	Food security	Diets & Nutrition	Food prices	Income Employment	Marginalized groups	Wastewater	Floods/Erosions	UHI effects	GHG emissions	Chemical fertilizers/ pesticides	Carbon sequestration	Landfill volume
Rosario	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0625	0,0000	0,0000	0,0000
Nairobi	0,0000	0,0000	0,0000	0,3750	0,0000	0,0125	0,0125	0,0000	-0,0125	0,0000	0,0000	0,0000
Lima	0,0000	0,0000	0,0000	0,0000	0,0000	0,0125	0,0125	0,0000	0,0000	0,0000	0,0000	0,0000
Kampala	0,0000	0,0000	0,0000	0,0000	0,0000	0,0125	0,0000	0,0000	-0,0125	0,0000	0,0000	0,0000
Accra	0,0000	0,0000	0,0000	0,0000	0,0000	0,0125	0,0125	0,0000	-0,0125	-0,0125	0,0000	0,0000
Hanoi	0,0000	0,0000	0,0000	-0,0125	0,0000	0,0125	0,0000	0,0000	-0,0125	0,0000	0,0000	0,0000
Phnom Penh	0,0000	0,0000	0,0000	-0,0125	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Havana	0,0000	0,0000	0,0000	-0,0125	0,0000	0,0125	0,0125	0,0000	-0,0125	-0,0125	0,0000	0,0000
Kesbewa	0,0000	0,0000	0,0000	0,0000	0,0000	-0,7500	-0,0500	0,0000	0,0000	0,0250	0,0000	0,0000

Source: own elaboration

Estratto per riassunto della tesi di dottorato

Studente: Francesca Grossi **matricola:** 956092

Dottorato: In Scienza e Gestione dei Cambiamenti Climatici

Ciclo: 29° ciclo

Titolo della tesi: Climate Smart Agriculture – Beyond the theoretical definition

Abstract:
It has been long recognized that effective climate policies need to account for economic, environmental and social impacts, exemplifying the notion of *"triple-wins"*. In the context, of rapid population growth and urbanization rate, this rationale has acquired even more impetus through the notion of *climate smart agriculture* applied to urban and peri-urban agriculture (UPA), i.e. farming practices that take place within or on the fringe of a city. Notwithstanding, this increasing popularity of UPA as climate-smart strategy, substantial challenges still remain, especially in terms of impacts' assessment. This research aims to contribute to fill existing knowledge gaps, through the development of triple-wins comparative analysis, enabling the practical investigation of UPA´s impacts, and thus a better understanding of whether and to which extent these farming practices can support the building of more resilient and sustainable cities in low and middle-income countries. Accordingly, it builds upon a multi-methods research design comprising of: qualitative content analysis, case study research, and a multiple criteria decision analysis method, the PROMETHEE II.

Firma dello studente

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Ciclo: 29° ciclo

Titolo della tesi: Climate Smart Agriculture – Beyond the theoretical definition

Abstract:

È da tempo riconosciuto che per poter parlare di politiche climatiche efficaci occorre considerare gli impatti a livello economico, ambientale e sociale, esemplificando la nozione di "triple-wins" traducibile in italiano tramite il concetto di "impatti triplici". Grazie alla rapida crescita demografica ed urbana, tale logica ha acquisito maggior impulso attraverso il concetto di *"climate-smart agriculture"*, applicato sia alle pratiche di agricoltura urbana sia a quelle di agricoltura periurbana. Nonostante la sua crescente popolarità, ancor' oggi sussistono molteplici lacune analitiche, in merito alla valutazione concreta dei triplici impatti di questo tipo di pratiche. L'elaborato mediante un analisi comparativa, mira ad evidenziare e colmare tali mancanze attraverso lo studio specifico degli stessi. Tramite un approccio analitico multi-metodo, mediante un' analisi qualitativa dei contenuti, una revisione di casi studio e l'utilizzo del metodo PROMETHEE II, si evidenzia come il grado e la misura delle pratiche agricole sopra citate contribuiscono a sostenere la costruzione di città più resilienti e sostenibili.

Firma dello studente

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