ADAPTING TO CLIMATE CHANGE IN COASTAL DAR ES SALAAM

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Keywords: climate change, adaptation, Sub-Saharan cities

ABSTRACT

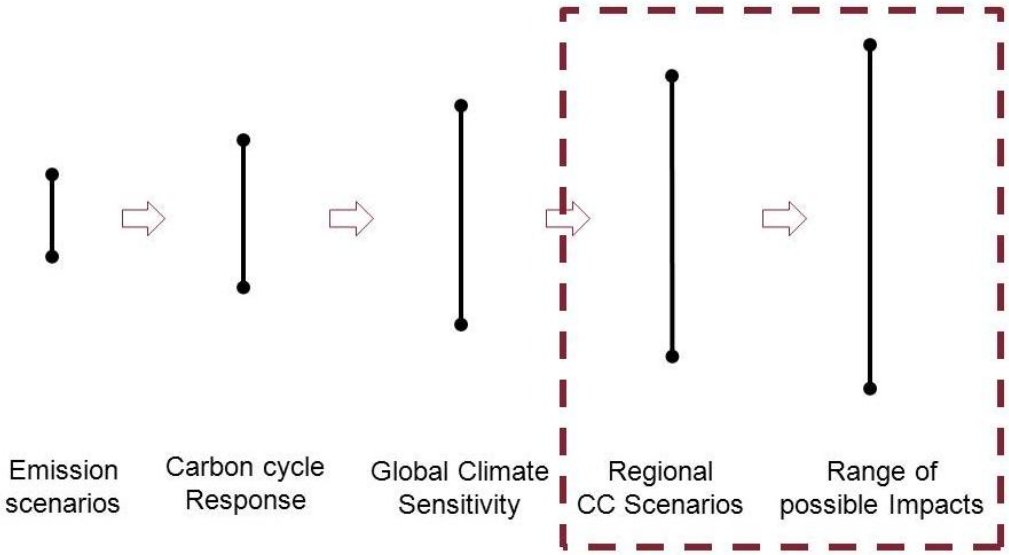
Urban adaptation to climate change is a field of growing interest in spatial planning and it is especially concerned with ways to cope with uncertainty inherent in regional downscaling of global prediction and, overall, in the response of the city to change. The paper presents the results of several research studies conducted in Dar es Salaam, Tanzania, with the twofold aim of increasing understanding of adaptation practices and developing methodologies for mainstreaming adaptation into urban development and environment management plans and programs. More specifically, the paper discusses the progress made by the research team in two directions: firstly, the enhancement of knowledge of the relationship between urban sprawl and climate change vulnerability in coastal Dar es Salaam; secondly, the development of a scenario methodology to support local governments in preparing long-term adaptation strategies for fighting groundwater salinization in a perspective of water resource conservation

1 INTRODUCTION)

Following the finalization of the Tanzania's National Adaptation Programme of Action (URT, 2007), an EU funded project has been launched in 2011 to improve the capacity of local governments (LGAs) to prepare Local Adaptation Plans of Action (LAPAs) for the peri-urban neighborhoods located on the coastal plain of Dar es Salaam.
The project, entitled Adapting to Climate Change in Coastal Dar es Salaam (ACC DAR), aims among other things to develop a locally tailored approach to the participatory design of adaption initiatives in the field of Urban Development and Environment Management (UDEM). To achieve this, a few assumptions were made.
Firstly, LAPAs are likely to be ineffective unless the "gap between planning and implementation" affecting most UDEM initiatives in African cities (Friedman, 2005) is acknowledged and tackled accordingly. Consequently, rather than preparing additional plans specific to adaptation, the decision was made to mainstream adaptation into existing UDEM plans and programs while considering the demand for adaptation as an opportunity to enhance their effectiveness.
Secondly, evidences from Sub-Saharan cities show the relentless effort of people to cope with environmental change (Simon, 2010), acting autonomously from and sometimes at odds with the LGAs. Due to their strong dependence on natural resources, urban and especially peri-urban households are adopting a variety of practices to maintain their actual livelihood strategies or gradually modify them to cope with environmental changes. We assume households' knowledge and expertise, along with those of local officers working with/for residents on daily basis, as an asset to LGAs in enhancing their UDEM strategies while mainstreaming adaptation objectives.
At the current state of the project, the main challenge at stake is how to define adaptation objectives that meet both needs and future aspirations of peri-urban residents. To this purpose, a participatory method is under development, combining Auguste Boal's forum theatre technique and backcasting approach to scenario analysis. While the former has been

identified as participatory technique suitable for exploring people's living experience in face of environmental changes, the latter seems to be a promising approach to overcome the undecidability generated by the Cascade of Uncertainty (IPPC, 2001) which characterizes the assessment of climate change future consequences following a mere probabilistic approach (Figure 1).

Figure 1. The Cascade of Uncertainty



After illustrating the concept framework developed by the Italian-Tanzanian joint research team, the paper will provide an overview of results achieved to date while highlighting open issues related to possible pathways for dealing with uncertainty in planning.

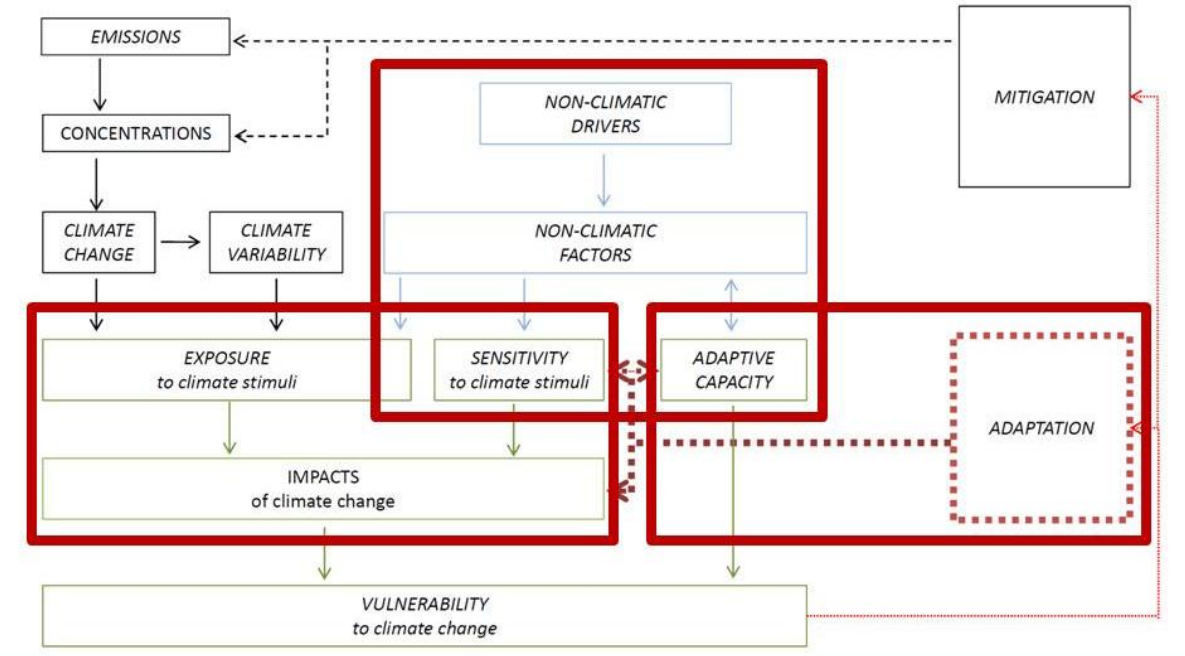
2 CONCEPTUAL FRAMEWORK AND METHODOLOGY

In the 1992 United Nations Framework Convention on Climate Change (UNFCCC), at article 1, climate change was defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." Even if this definition has been later reviewed by the Intergovernmental Panel on Climate Change (IPCC, 2001) in order to include all long-term climate changes irrespectively of whether due to natural variability or as a result of human activity, the international commitment to mitigate climate change through the reduction of its human drivers has become ever stronger over the last two decades. The same cannot be said for adaptation, a strategy that should complement mitigation in meeting the ultimate objective of the UNFCCC. Adaptation refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change (IPPC, 2001). In fact, the majority of research and policy efforts have been devoted to how to stabilize the concentration of greenhouse gases in the atmosphere (Klein, Schipper, Dessai, 2005), whereas the commitment to adaptation has become tangible only since the Bali Conference of Parties (2007) under the pressure of the least developed countries which suffer from the effects of climate change without being responsible for it.

This slow movement towards an integrated approach addressing simultaneously mitigation and adaptation concerns has been accompanied by a progressive complexification of conceptual frameworks for the assessment of vulnerability to climate change (Füssel e Klein, 2006). At the same time, growing attention has been paid to local "adaptive capacity" defined as "the ability of a system to adjust to climate change (including climate variability and

extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC, 2001: 21). In this paper, we will apply the framework proposed by Füssel e Klein (2006) that appears to be a major reference for spatial planning in Europe (2011a). In particular, the research activities conducted within the ACC DAR project focus on the four areas circled in red in figure 2.

Figure 2. Conceptual framework for the assessment of vulnerability to climate change



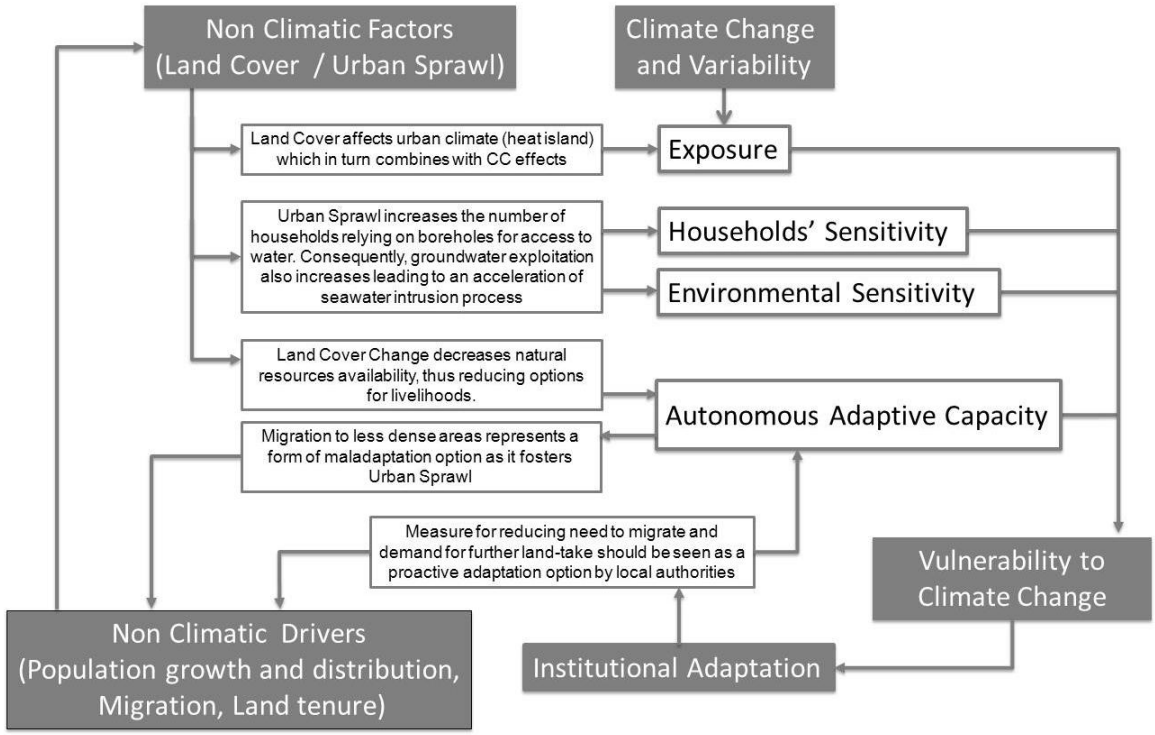
The ACC DAR project assumes that strengthening the local adaptive capacity is the only viable solution in Dar es Salaam to reduce people's vulnerability to climate change's future effects. The reasons for this are two-fold. Firstly, the financial effort required to modify in the short term the other two components of vulnerability, notably exposure and sensitivity, appears to be unbearable for Dar es Salaam's LGAs to carry. Secondly, the uncertainty associated to the forecast of climate change's local effects obtained through the regional downscaling of global predictions is too high to support immediate decision-making for such investments. Uncertainties about whether the sea level will rise or fall in the future are an example of that (Kebede and Nicholls, 2012).

More specifically, an emphasis is placed on ways to maintain and improve those components of local adaptive capacity that allow people to put in place autonomously adaptive strategies in response to changes in their living environment (Nelson, Adger, Brown, 2007; Hallegatte, 2009; Engle, 2011). Furthermore, among the possible forms of autonomous adaptation, a distinction is made between adaptation and maladaptation, that is initiatives in response to environmental changes bearing negative consequences for vulnerability (Barnett, O'Neill, 2010).

Surveys conducted under the ACC DAR project show that groundwater salinization is a major concern for households living in peri-urban neighborhoods within the coastal plain (Ricci et al., 2012). In fact, most of them depend heavily on boreholes for access to water for domestic and productive (mostly agriculture-related) purposes. Such dependence is absolute for households living in under-serviced areas that do not have access to alternative water sources (such as street vendors or natural streams), and all peri-urban households are affected to a certain extent, as piped water service is intermittent and water sold by private vendors is expensive. Notwithstanding the social importance of groundwater availability, the studies on seawater intrusion in the coastal shallow aquifer are scarce and none have developed future scenarios under climatic and non-climatic changes, to our knowledge.

The ACC DAR research team has hence taken on the duty of contributing to closing this knowledge gap and of bringing the seawater intrusion phenomenon to the attention of LGAs as a major issue for adaptation planning. Accordingly, several research studies have been undertaken to assess changes in past recharge and pumping rates in order to develop a hydrogeological balance (Coviello et al., 2013) and to explore the complex interplay between urban sprawl and climate change adaptation (Congedo et al., 2013), since land cover change might be the most important non-climatic factor that influences future groundwater availability (Figure 3).

Figure 3. Relationship between LCC and climate change vulnerability in coastal Dar es Salaam



In climate change adaptation literature (IPPC, 2012) it is widely acknowledged that the assessment of vulnerability should be based on the analysis of the interaction of climatic, environmental, and human factors. In fact, reducing vulnerability also means addressing its underlying drivers, which include, besides climate change effects, those non-climatic factors that play an important role in determining impacts and shaping adaptive capacity.

The relevance of non-climatic factors is especially evident in urban areas, notwithstanding the differences among regions and countries. Settlement patterns, urbanization, and changes in socioeconomic conditions all influence the three key components of vulnerability, i.e. exposure, sensitivity, and adaptive capacity. As a special feature of developing countries, rapid urbanization and the growth of megacities have led to the emergence of highly vulnerable urban communities, particularly through informal settlements and inadequate land management.

Urbanization itself is not always a driver of increased vulnerability. Instead, the type of urbanization and the context in which urbanization is embedded defines whether these processes contribute to an increase or decrease in people's vulnerability. Development planning, including land use and urban planning, river basin and land management, hazard-resistant building codes, and landscape design are all activities that can reduce exposure and vulnerability to hazards and change (Cardona et al., 2012). The ability to carry these activities out in an effective way is part of local capacity for adaptation, but all of them need

time to produce significant effects and require a significant effort to develop future scenarios under conditions of climate change and continuous urban sprawl.
The research seeks to contribute to this effort. More precisely, the paper discusses the progress made by the research team in two directions:

- the enhancement of knowledge of the relationship between urban sprawl and climate change vulnerability in coastal Dar es Salaam.
- the development of a scenario methodology to support LGAs in preparing long-term adaptation strategies for fighting groundwater salinization in a perspective of water resource conservation

3 ANALYSIS AND DISCUSSION OF RESULTS

3.1 Migration Patterns in Peri-urban Dar es Salaam

Geographical and environmental factors, particularly climate change, have influenced the urbanization process in Africa more than in other contexts. The process of urbanization has therefore also been the result of the flight from difficult environmental conditions rather than a migration towards cities viewed as attractive for their economic and social opportunities (Annez, Buckly and Kalarickal, 2010; Tacoli, 1998; Parenti, 2011).
Although most of the literature on migration in sub-Saharan cities emphasizes rural to urban and peri-urban to urban flows as typical migration patterns and drivers of urban sprawl (Mattingly, 2009)[1], the case of Dar es Salaam highlights that migration flows can be more complex, dynamic, and multidirectional (Kombe, 2005; Ricci, 2011; Norero, 2012).
Peri-urban areas play a crucial role in the migration process in Dar es Salaam, both because they represent most of the city region and because it is there that urban and environmental changes occur more quickly and are more evident (e.g. they host most of the planned and unplanned urban development and they experience the more evident changes in natural resource quality and availability).
According to several surveys conducted in 2009-2011, migration flows in Dar es Salaam move in different directions, as follows (Figure 4):

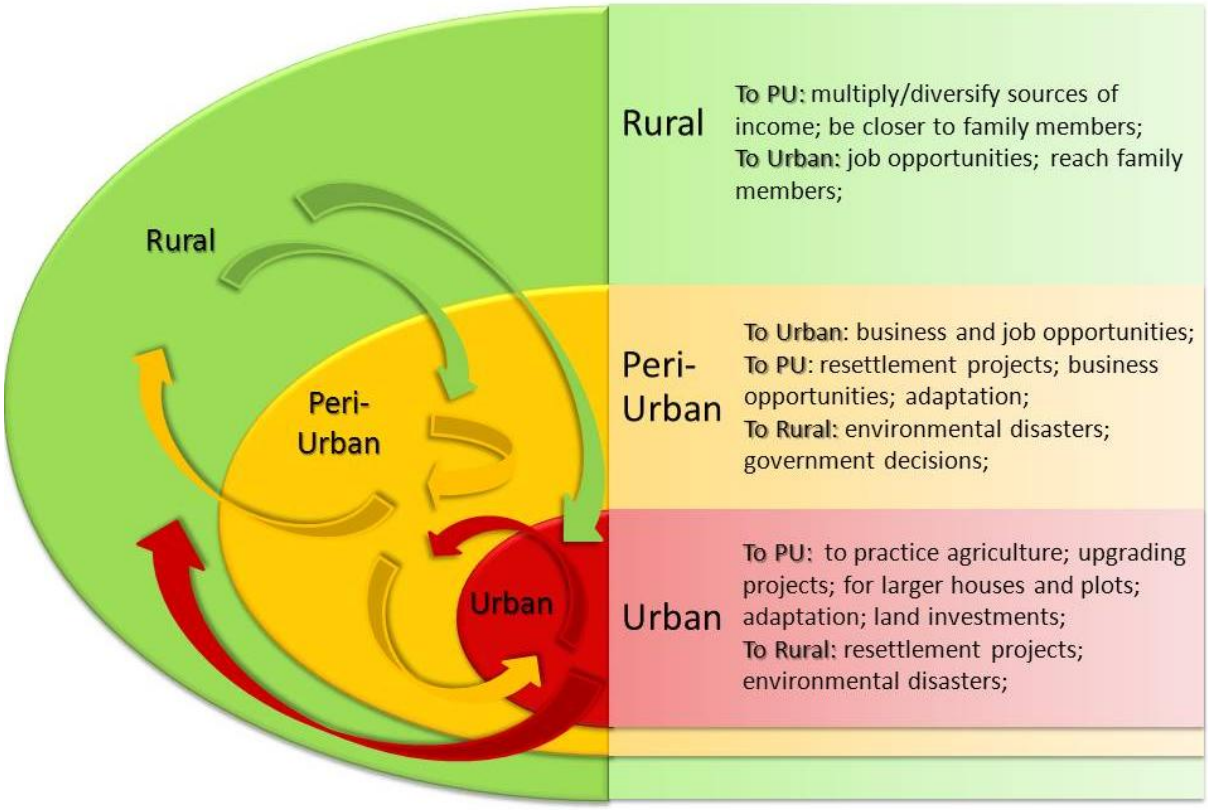
- Rural to urban
- Rural to peri-urban
- Urban to peri-urban
- Urban to urban
- Peri-urban to urban
- Peri-urban to peri-urban
- Peri-urban to rural

Although each of these migration patterns is relevant to the peri-urban expansion (urban sprawl) that has occurred in Dar es Salaam, particularly in the last decade, the ACC DAR Project focuses on migration to the peri-urban in order to understand i) to what extent migration from rural and urban areas as well as within peri-urban areas contributes to peri-urban expansion; and ii) if and how migration to the peri-urban represents an option for coping with present and future environmental changes at the household level.
A survey conducted in 2011 of roughly 6000 households settled in Dar es Salaam peri-urban areas (Ricci et al., 2012) has provided evidence that only a portion of households surveyed moved from other Tanzanian regions (36%) (rural to peri-urban) while the majority (64%) moved from another municipality in the Dar es Salaam region (34%) or from another location within the same municipality (30%) (urban to peri-urban or peri-urban to peri-urban).

[1] The legacy of the old theory of urban parasitism, there remains a shared belief that peri-urban areas are the destination of migrants from rural areas who settle there temporarily because of lower costs and the possibility of producing their own food, while waiting for a high enough urban wage to move into a serviced neighbourhood.

According to these results, the development of peri-urban areas is mainly linked to internal migration within the city region rather than to rural-to-urban flows.

Figure 4. migration patterns in Dar es Salaam



During the household survey, many respondents (35%) indicated purchasing of a piece of land as their reason for moving to where they currently live. Most of them come from the city region and even from the same municipality, leading to the hypothesis that they moved in order to increase their property. It is worth noting that a number of studies (Briggs and Mwamfupe, 2000; Kombe, 2005; Mbiba and Huchzermeyer, 2002; Lupala, 2002) revealed the movement of medium- and high-income households from urban to peri-urban areas. Their transfer to peri-urban areas has been favoured (and probably still is) not only by improved accessibility due to the liberalization of the transportation system, but also by the existence of housing subsidies provided to government employees, and by the availability of low-cost land, which has led to a veritable construction boom in some peri-urban areas (Briggs and Mwamfupe, 2000). Thus, for medium- and high-income people from urban areas, investments in construction constitute a means of overcoming economic difficulty, securing their savings, and investing profitably[2]. People also move away from the city centre (urban) to peri-urban areas in response to pressures created by urban development and land-tenure formalization processes. Upgrading and rehabilitation projects result in increased land value, which creates a chance for low-income residents to sell their land and invest gains in a bigger plot in the peri-urban (mainly unsurveyed areas).

[2] The combined effects of the 1980s economic crisis and subsequent structural adjustments led to increased commercialization of the land in peri-urban areas during the 90s (Briggs and Mwamfupe, 2000), transforming such areas from “a zone of survival” to “a zone for investment” (Mbiba and Huchzermeyer, 2002: 120). This process, which was further fostered by the regulatory transition from customary to formally institutionalized forms of land tenure (Land Act 1999), resulted in the marginalization of the poorest urban groups and aggravation of conflicts over access to land.

As regards the other drivers for migration, the household survey reveals that a number of households, mainly those from other Tanzanian regions (rural to urban or peri-urban), also moved to look for a job (21%) or for self-employment (15%). Others moved for business purposes (9%) or to find an area with more space in which to live and work (e.g. to have the possibility of practicing agriculture or free husbandry). Peri-urban areas attract people seeking a place to start or continue rural activities while simultaneously being close to urban dynamics, benefits, and facilities. In these areas, the low cost of living, the possibility of diversifying income generating activities, and the easier access to natural resources enable people to benefit from both rural and urban opportunities while maintaining a good level of flexibility, an important resource, particularly when faced with environmental stresses.

Besides "spontaneous" movements, migration can be generated by events beyond the household's control. The survey shows that some people were required to move because of a job transfer (8%) or government decision (1%). Cases falling in the latter category include the displacement of people located in hazard areas (e.g. flood prone areas), which can be considered a form of institutional adaptation. After the flooding of December 2011, approximately 1800 families residing in semi-central neighbourhoods around the river Msimbazi basin were resettled in Mabwepande village, 37 km from the city centre. Although this type of migration is not common in Dar es Salaam, the increase in extreme events and general worsening of environmental conditions could lead the government to adopt these kinds of measures more frequently in the future. Other government decisions that can lead to migration include upgrading or urban development projects, which can involve the relocation of people living in low standard housing or the imposition of higher standards for plot redevelopment (e.g. multi-storey buildings, access to electricity network and other infrastructures, etc.), which forces residents who cannot afford the required investment to migrate.

The questionnaire administered in 2011 also investigated the adaptation practices households intended to use in case of future environmental changes in their place of residence. Analysis results indicate that 26% of the interviewees would move to another area if the environmental conditions (e.g. soil fertility, water availability, …) of their living place deteriorate. So, migration seems to be an important option for coping with future environmental changes, which leads to the conclusion that climate change is likely to become a growing driver of urban sprawl as its effects in Dar es Salaam become more pronounced.

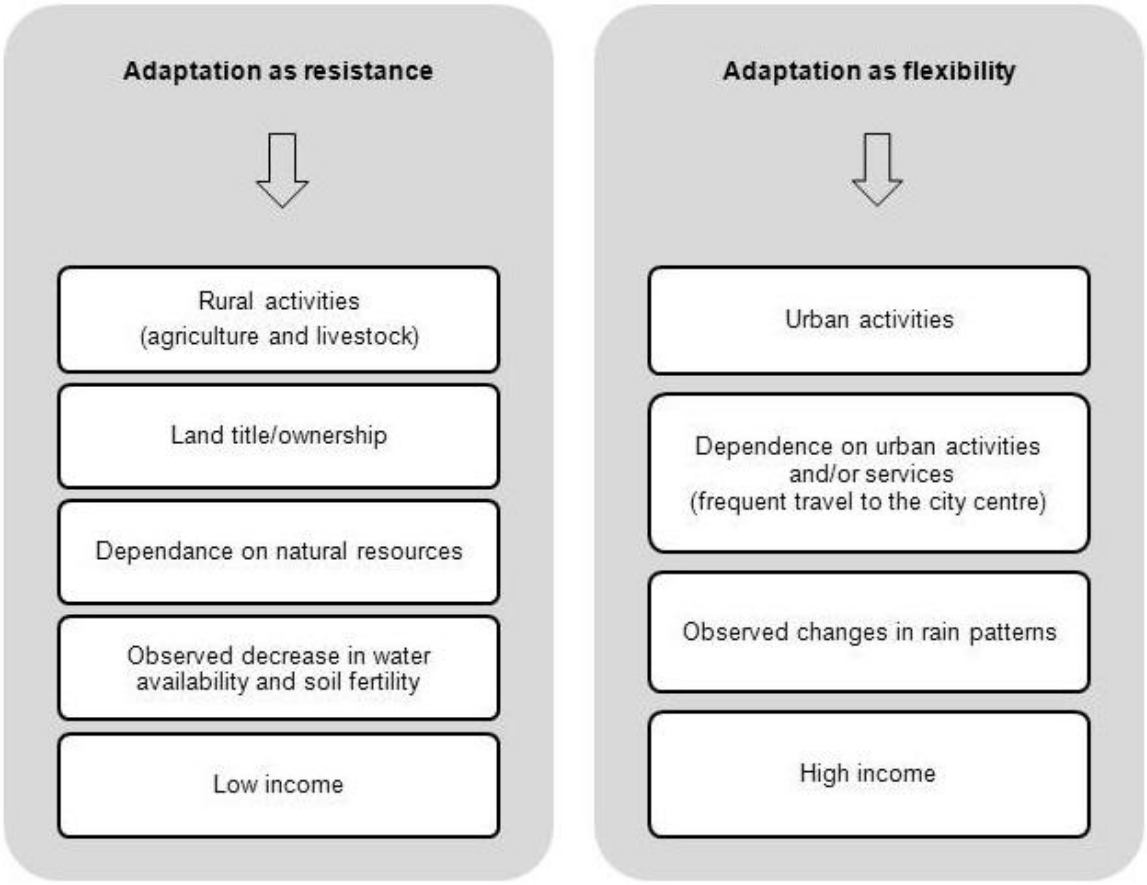
According to the analysis performed on the data collected in 2011, two types of adaptation profiles can be discerned, as displayed in Figure 5.

The first profile type describes households engaged in adaptation strategies that are more oriented to "resistance", to staying in the same place, improving or intensifying the activities they are already practicing, and physically modifying their land and house according to environmental changes. Those households usually practice rural activities as their main source of income or as secondary activities, and typically have ownership or a title deed for their land. They are totally or partially dependent on natural resources and have a low mean income. Furthermore, being engaged in agriculture and livestock, they observe considerable changes in water availability and soil fertility.

The second profile type, which we termed as "flexible", describes households who are likely to move to other places, to change their income activities and to modify their livelihood arrangements in case of major changes in their living environment. They are engaged mainly in urban activities, have a strong dependence on the city centre and a high mean income as compared with the other profile type. The environmental changes they observe are mainly variations in rain patterns.

It is worth mentioning that migration is a common strategy for adaptation to environmental change in Sub-Saharan Africa (FORESIGHT, 2011). People living in deteriorating areas migrate to other zones, altering the environment (e.g. deforestation, urbanization) and actually increasing vulnerability.

Figure 5. Household characteristics by adaptation profile



In conclusion, migration flows contribute in several ways to urban sprawl in Dar es Salaam. While migration from the rural inland undeniably plays a role in demographic growth at the city region level, the investment opportunities and multiple adaptation options offered by peri-urban areas represent important pull factors for old and new residents. At the same time, environmental change and urban development act as push factors. It is worth noting that migration to the peri-urban increases the anthropogenic pressures and impacts on natural resources, which may accelerate or amplify the effects of climate change (e.g. watershed salinization). This leads to the conclusion that the "flexible" adaptation strategies identified by residents are in fact forms of autonomous mal-adaptation, and as such should be a target for institutional adaptation.

3.2 Relationship between Population Growth, Settlement Patterns, and Urban Sprawl

Following the findings on migration flows and their link to urban sprawl, an in-depth study of Land Cover Change (LCC) was undertaken to better understand the role played by population growth and urban development patterns in fostering the expansion of the peri-urban in Dar es Salaam.
In order to assess LCC over the last decade, several low-cost and easy to use tools and methods were defined. LC classifications were produced by applying a semi-automatic procedure to freely available Landsat imagery. Since a 900m^2 pixel was considered small enough to capture the required detail while large enough to ensure computer storage and analysis be performed efficiently, images with a spatial resolution of 30m were selected (Congedo & Munafò, 2012).

Urban developed areas were classified as follows:

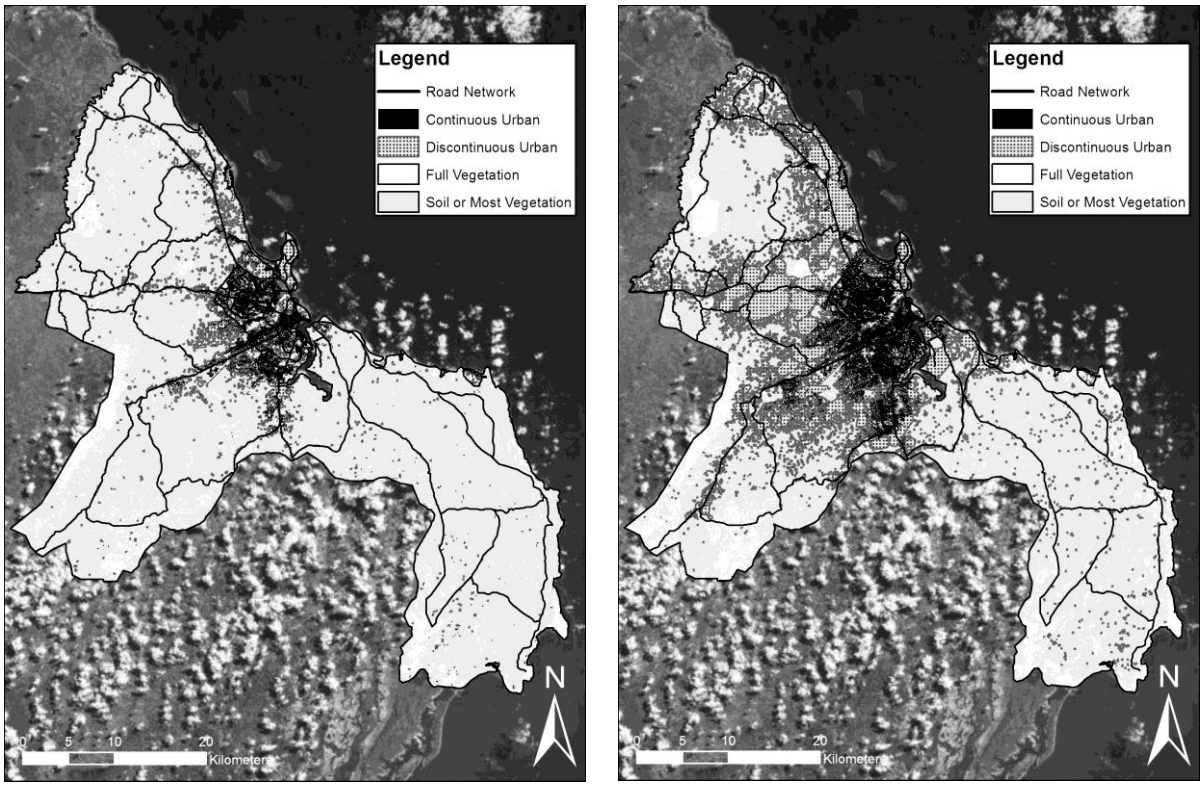
- Continuously Built-up: a densely developed class, whose pixels are characterized by homogeneity of urban cover;
- Discontinuously Built-up: a low-density development class, whose mixed pixels are characterized by a variety of land cover types, including urbanized, vegetation, and bare soil.

As indicated in Table 1 and illustrated in Figure 6, built-up areas increased by 133% during 2002-2011, reaching 38,486 hectares (around 25% of the regional territory), whereas the population grew by only 75% during 2002-2012 (see Figure 6). The two classifications of built-up development have been subject to different rates of change: “Continuously Built-up” areas increased by 76%, while “Discontinuously Built-up” ones grew by 192%.

Table 1: Area in hectares of built-up land cover classes and percentage of growth since 2002

Class	2002	2004	2007	2009	2011
Continuously Built-up	8,415	10,025 (+19%)	10,447 (+24%)	12,370 (+47%)	14,808 (+76%)
Discontinuously Built-up	8,098	9,134 (+13%)	12,509 (+54%)	17,318 (+114%)	23,678 (+192%)
Total Built-up areas	16,513	19,159 (+16%)	22,956 (+39%)	29,688 (+80%)	38,486 (+133%)

Figure 6. Land Cover classification of Dar es Salaam region, 2002 and 2011



This considerable increase in low-density areas is related to the urban sprawl phenomenon, particularly along the main thoroughfares. It should be noted that the “Discontinuously Built-up” class includes all low-density settlements, with no regard for whether they are planned or

not. However, planned settlements represent the absolute minority of low-density developed areas in Dar es Salaam. Consequently, it is reasonable to assume the “Discontinuously Built-up” class as a proxy for urban sprawl.
An Urban Sprawl Indicator (ESPON, 2011), which highlights the importance of low-density development patterns as compared to high-density ones, has been calculated as follows:

Urban Sprawl Indicator = [(Discontinuously Built-up area) / (Total Urban area)] * 100

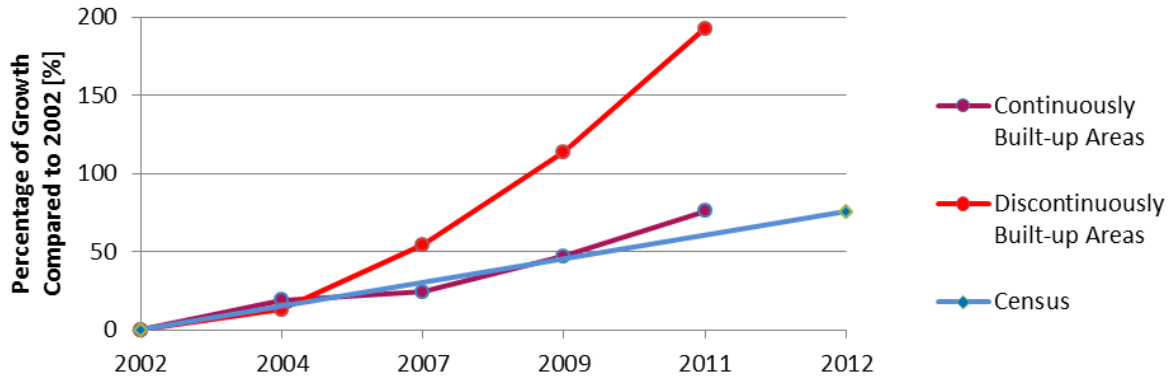
Table 2 indicates that indicator values are increasing over time, demonstrating that the city is sprawling rather than densifying.

Table 2: Periodic Urban Sprawl Indicators (2002-2011)

Year	2002	2004	2007	2009	2011
Urban Sprawl Indicator [%]	49.0	47.7	54.5	58.3	61.5

The line graph in Figure 7 compares the evolution of “Continuously Built-up” and “Discontinuously Built-up” areas with population, as indicated in the 2002 and 2012 census results. The trends observed in Dar es Salaam are in conformity with the UN-HABITAT (2010) definition of urban sprawl as a visible misalignment of population growth and the physical expansion of the city. In particular, while the “Continuous Built-up” has trended in a similar way to population growth, the increase of “Discontinuously Built-up” areas far exceeds demographic growth. This leads to the hypothesis that the relationship between demographic growth and physical expansion is mediated by the settlement pattern that dominates in newly developed areas.

Figure 7. Comparison of demographic and urban growth



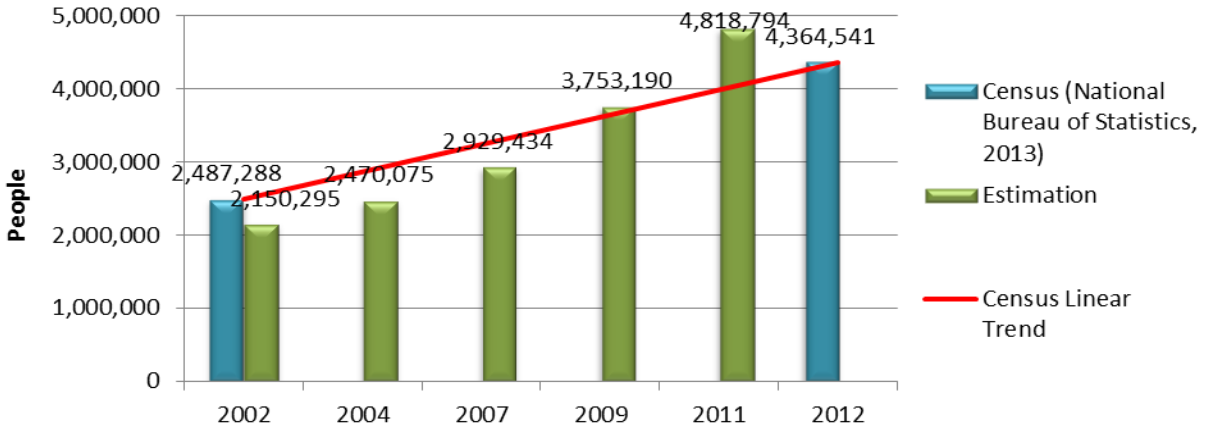
In order to explore the relationship between demographic growth, settlement patterns, and the physical expansion of the city, a methodology for estimating population has been developed. The methodology assumes that household density for each LC class remains constant over the studied period, which implies that total population is equal to the sum of each LC class area multiplied by the respective household density.

Population estimate = sum [(Area * Household Density)$_{class\ i}$] * Average Household Size

Accordingly, population estimates were calculated for 2002, 2004, 2007, 2009, and 2011, using the LC classification previously developed and the household density by LC class extrapolated from the household survey conducted in 2011 (Congedo, Munafò, and Macchi, 2013).

Figure 8 shows the results thus achieved, and compares them to census data for years 2002 and 2012 (United Republic of Tanzania, 2013). Considering a linear trend between the 2002 and 2012 census, estimates are quite reliable, with a margin of error of ±15%. However, one can also note that the estimate for 2002 is below the census value, whereas the 2011 estimate is above it. Since the population has been calculated from LC classifications, this suggests that the relationship between LC and population growth has changed over the last decade, with urban expansion becoming less dependent on demographic growth.

Figure 8. Comparison of census data with estimation



The next step in the research project will involve addressing the question of what other factors, besides population growth and settlement patterns, are emerging as drivers for urban sprawl in Dar es Salaam. To date, two research directions have been identified: first, to further explore the series of factors that lead to a reduction of settlement density in residential neighbourhoods, such as increasing middle class' living standards and the tendency to build more than one house per family for investment reasons, combined with the wish to grab more land than needed; second, to examine the rapid proliferation of non-residential activities in both urban and peri-urban areas, especially construction of tourism facilities along the coastline, as well as retail, office or manufacturing spaces within the coastal plain.

3.3 Towards a Scenario Analysis Methodology for Climate Change Adaptation

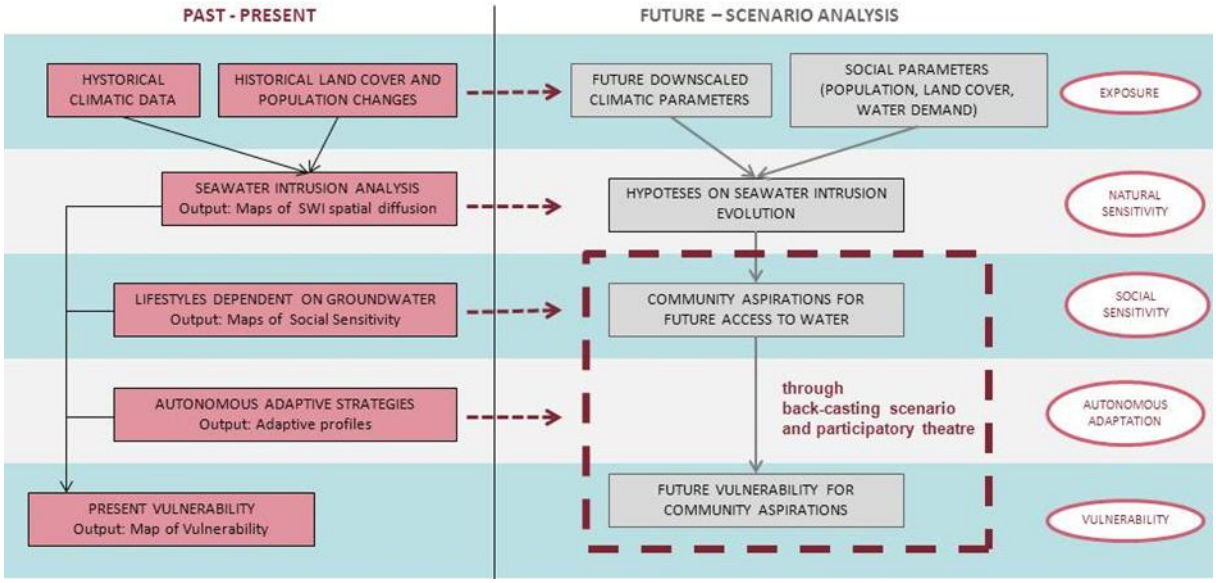
In order to address the issues of future uncertainly and socio-economic, environmental, and climatic system complexity in urban CC adaptation planning, the research employs scenario analysis methods. These are particularly useful in anticipating and shaping the future for highly uncertain and difficult to control situations, and are increasingly used by researchers and policy makers to design adaptation strategies (Peterson et al., 2003; Börjeson et al., 2006).

In this paper the term "scenario analysis" refers to a set of methodologies through which plausible stories and images of the future (scenarios) are built and used to inform decision-making and planning in a wide range of organizational and policy making contexts (Shoemaker, 1995). The field of futures studies encompasses a variety of techniques for scenario development, which differ widely in terms of objective, method, content, and "philosophical" approach (Van Notten et al., 2003).

The ACC DAR Project focuses on water resource management in the coastal plain of Dar es Salaam, with the aim of supporting LGAs in preparing long-term adaptation strategies for fighting groundwater salinization in a perspective of water resource conservation. To that end, a scenario methodology has been developed that employs two different approaches in order to deal with different types of uncertainty:

- the forecasting approach (exploratory scenario: What could happen?), used for developing hypotheses regarding the future evolution of the biophysical system;
- the backcasting approach (normative scenario: How can a specific target be reached?), used for defining adaptation objectives at the community level.

Figure 9. ACC DAR workflow activity diagram



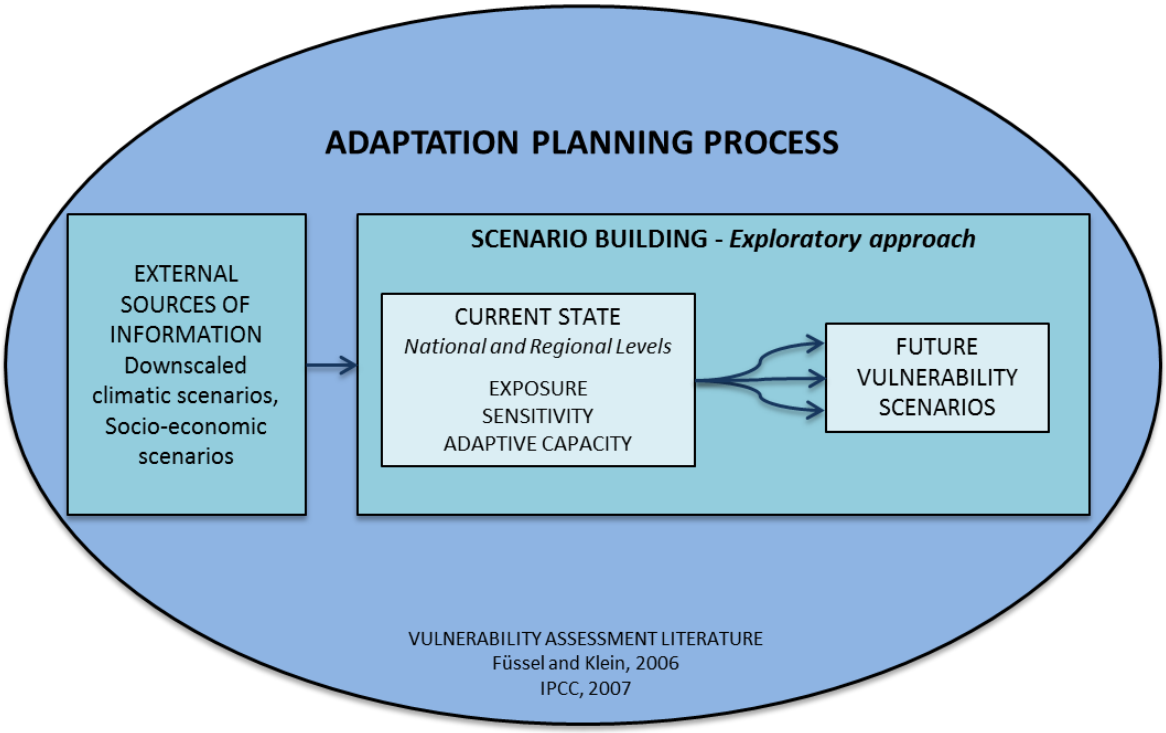
The forecasting approach originates in the strategic planning field. Within this approach, scenario analysis articulates plausible future societal developments, explores pathways from the present to the future, and postulates possible consequences of a given phenomenon. It can be used as a learning process aimed at understanding problem boundaries, key trends and drivers, and exploring the implications that arise from the application of long-term strategies. Notwithstanding the substantial differences between various scenario building methods (top-down vs. bottom-up, quantitative vs. qualitative, analytical vs. participatory), the forecasting approach has played a dominant role in informing climate change impacts and vulnerability assessments for adaptation, especially at the national and regional levels (e.g. SRES scenarios, socio-economic scenarios, down-scaled climatic scenarios) (Swart et al., 2004).

The backcasting approach originates in the field of energy studies and can be currently placed within the sphere of sustainability planning. Within this approach, scenario analysis involves the development of desirable future visions, and then looks backwards from that future to the present in order to individuate the strategies and actions, including system change actions, for achieving that future (Dreborg, 1996; Vergragt and Quist, 2011). A recent evolution of this approach is participatory backcasting (Robinson, 2003; Quist and Vergragt, 2006), which is based on the involvement of different stakeholders in creating the future vision and developing future-present pathways. Although the backcasting approach has recently achieved prominence in transition management studies, in terms of technological (Rotmans et al., 2001) and urban transition ("Transition Towns"), its use in adaptation planning has not yet been widely experimented.

Within the ACC DAR methodology, the forecasting approach is used for the exploration of plausible present-future trajectories of coastal aquifer salinization, in relation with the possible evolution of climatic (i.e. decreasing rainfall and increasing air temperature) and non-climatic drivers (i.e. population growth, internal migration, prevailing settlement patterns, water demand evolution). This approach appears to be more suitable for the investigation of path-dependent systems, such as biophysical ones. In fact, despite the uncertainty surrounding future pressure factors, they exhibit a sufficient degree of structural consistency

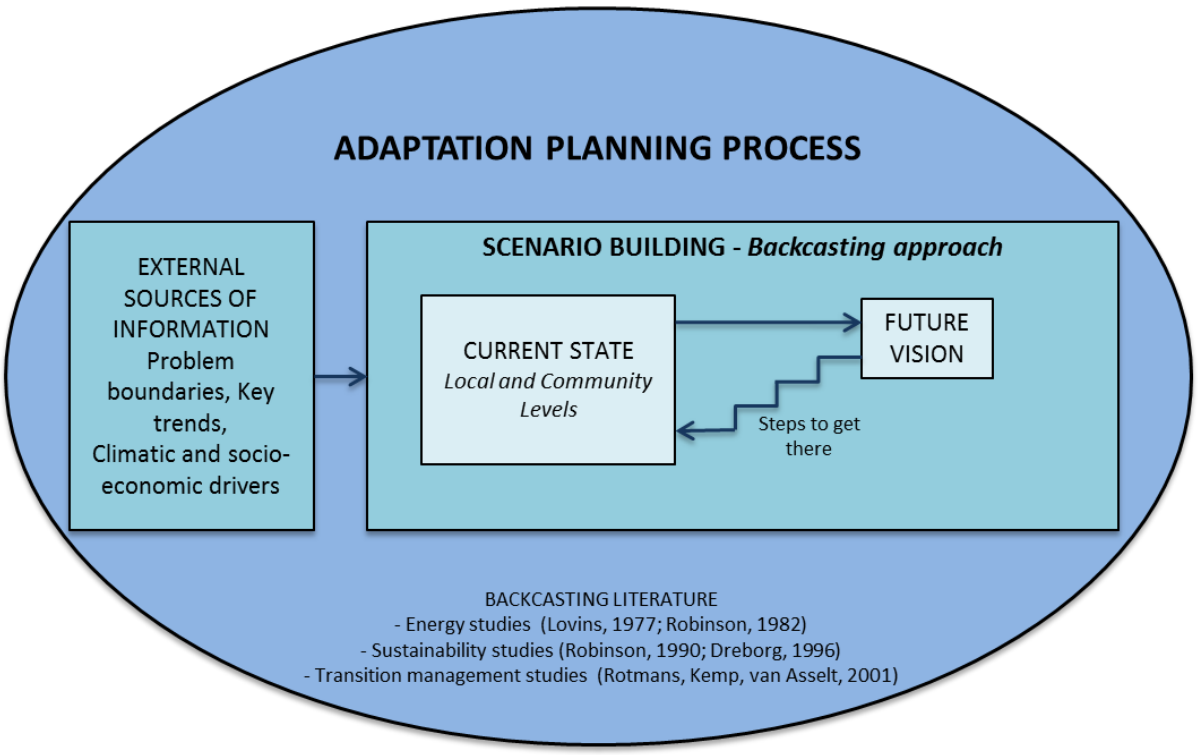
over time to define plausible hypotheses of future behaviour. Through the use of the forecasting approach, it is therefore possible to recognize the dynamics and relationships between different factors of pressure on the system, as well as the boundary conditions of the problem under study. However, this approach is not suitable to support transformative planning processes or define adaptation objectives at the community level, for several reasons. Firstly, it is based on dominant trends that may not apply in a specific local context. Secondly, the adaptation objectives that would result from its use in the planning process - even if valid and ambitious - would necessarily be conservative, i.e. extrapolated from the present conditions of vulnerability. In fact, in the forecasting approach, vulnerability is considered as an intrinsic individual characteristic that heavily influences that person's future trajectory, leading to the rejection of any perspective on change in the very mechanism that reproduces it.

Figure 10. Conceptual framework for adaptation planning: the forecasting approach



Consequently, an additional level based on a participatory backcasting approach was included in the ACC DAR scenario methodology, pursuant to the hypothesis that this approach could contribute to the identification of transformative systemic projects oriented to sustainability and framed in the adaptation planning process. In the backcasting approach, vulnerability is considered a contextual characteristic, determined by the complex system of relationships that the individual develops with society and the environment. Due to the unpredictability of future vulnerability and people's legitimate expectations for change, the future is envisioned as a utopia, a desirable horizon beyond the current situation. By considering the present as just a starting state from which to achieve a desirable future, and thus detached from the current drivers of vulnerability, this approach combines the development of successful long-term climate adaptation strategies at the community level with the promotion of a systemic societal transition towards sustainability targets. In fact, the use of the backcasting scenario introduces into the adaptation planning process a dimension related to aspirations for change, which seems more suitable for addressing the problem of decision-making when faced with highly uncertain systems whose trajectory depends on human choice.

Figure 11. Conceptual framework for adaptation planning: the backcasting approach



More specifically, some features of participatory backcasting can assist communities and local agencies with various aspects of the adaptation planning process. The creation of a community vision for future development (or multiple visions ordered according to desirability) facilitates the definition of socially shared adaptation objectives, rather than extrapolating them from a context-neutral vulnerability assessment. In so doing, objectives are identified by maintaining a systemic perspective when considering the key features of natural and human systems and the different ways in which climate change can impact them. Community involvement in vision development fosters social learning, thus broadening the space for actions that incorporate different contextual values and preferences, and for the research on alternative livelihoods and potential agents of change. By flexibly connecting future objectives with adaptation actions to be undertaken in the present, the development of future-present pathways highlights the need for system transformative actions.

4 CONCLUSIONS

The studies conducted within the ACC DAR project provide indications for scenario analysis for adaptation planning under conditions of climate change and continuous urban sprawl, which are peculiar to coastal Sub-Saharan cities like Dar es Salaam.
In this perspective, there are at least two aspects of the relationship between climate change and urban sprawl that merit consideration:

- urban sprawl as a contradictory non-climatic factor;
- urban sprawl as part of a vicious circle linking migration to environmental degradation.

Each of these two points highlights certain differences between cities in the North and in the South of the world as concerns the relationship between climate change and urban sprawl, which calls into question the validity of a number of strategies that are currently taken for granted in the field of adaptation planning.
The twofold role played by the peri-urban, a source of environmental degradation as well as a means for residents to better cope with that same degradation, constitutes a dilemma for urban planners when dealing with cities like Dar es Salaam: the low density development

pattern may no longer be bad for urban resilience and, conversely, densification may no longer be the most effective strategy for adaptation to climate change. Instead, the advantages of fostering urban densification as a way of preserving the environmental services provided by natural ecosystems while facilitating institutional adaptation (from early warning systems to sustainable water management) and reducing the emission of GHGs (due to decreased travel distance) should be weighed against the disadvantages in terms of loss of autonomous adaptive capacity, which is fundamental for limiting people's vulnerability when the population growth rate is such that no local authority can afford to meet their settlement demands.

How can one resolve such dilemma? In our opinion, one possibility is to shift the conceptual focus from urban form (i.e. settlement density) to access to water in the peri-urban zone. The major reason in support of such a shift is that a plethora of factors limit the possibility of changing the actual settlement patterns of the majority of the population in Dar es Salaam. Besides the "attachment to rurality" of people who immigrated relatively recently from the inland, and the tendency of the emerging urban middle class to view peri-urban areas as an investment opportunity,, lack of financial means combined with the speed of urbanization poses an unmeetable challenge for government authorities seeking to create the infrastructures required for urban densification. It is worth noting that the involvement of private investors in this kind of process often results in the expulsion of the city's poorest, thus further fuelling urban sprawl. In addition, low-density development does not seem to compromise the soil's capacity to provide environmental services as much as it does in cities of the Global North. In fact, the degree of soil sealing associated with peri-urban settlement is quite low, as the plot surface is rarely paved and the peri-urban fabric in general includes large portion of natural spaces. So, ensuring sustainable access to water for peri-urban residents seems a more worthwhile and reachable goal than changing prevailing settlement patterns, at least in the short- to middle-term, and will also contribute to a reduction in groundwater extraction, which appears to be the most serious threat to the environment currently posed by urban sprawl.

As regards the second issue highlighted above, the vicious circle linking environmental degradation to urban sprawl leads one to consider the adaptation strategies that entail migration from urban and peri-urban areas to further peri-urban fringes as a form of maladaptation. To date, those strategies only represent a minor driver of urban sprawl in Dar es Salaam, since population growth combined with prevailing low-density settlement patterns appear to explain the city's physical expansion. Nevertheless, one may reasonably expect that the combined effects of climate change and urban middle class growth will spur the momentum of migration within the city region, as it represents the adaptation strategy favoured by households with an urban-based livelihood. While it is crucial to guarantee that households that are entirely or partially dependent on rural activities and free access to natural resources have the possibility to settle according to their needs, a different attitude would be advisable with respect to households for whom moving to the further peri-urban fringe is simply more convenient or profitable, as opposed to being indispensable for their livelihoods. Options for containing the maladaptation of the latter include, first of all, the creation of alternative opportunities for investment and/or savings. A second option, one that is more directly linked to urban planning, is to empower households in shaping the future of their neighbourhoods and raise their awareness of the consequences of adaptation through migration.

Lastly, lessons learned from both cases can be used to improve the use of scenario analysis when dealing with uncertainty in urban planning more generally. In fact, as scenario analysis is widely employed in climate change related planning, it is in this same field that its limits are being questioned today. In our opinion, the risk intrinsic to the forecasting approach when applied to adaptation is that it favours a conservative approach to defining planning objectives, since the purpose of adaptation is conservation of the status quo, in other words, adjustment of the current development model to avoid certain unwanted and annoying changes (Parenti, 2011). The backcasting approach would be an antidote to such risk, which

is crucial for cities whose rapid pace of development could provide unique opportunities to shape an optimal future.
The next step in the research project will be to explore, in practice, the implications and advantages of using a participatory backcasting approach for planning adaptation. More precisely, a scenario exercise will be conducted in a peri-urban settlement of Dar es Salaam by means of the participatory theatre technique, already tested in 2012 to explore adaptation options with groups of per-urban residents (Loddoni, 2013; Malcor, 2013).

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