Urban wildscapes and green spaces in Mombasa and their potential contribution to climate change adaptation and mitigation

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ABSTRACT Well-planned urban green landscapes, including wildscapes and green spaces, have the potential to contribute to climate change adaptation and mitigation. Yet for cities in low-income countries, the value of these urban landscapes in climate change response strategies is often disregarded and remains largely unexploited and unaccounted for. This paper discusses the potential role of urban green landscapes as a "soft engineering" climate change response strategy, and calls for the pursuance of management practices that preserve and promote the use of these urban spaces. It does so by combining theoretical arguments with an empirical example based on an innovative and novel approach to landscape rehabilitation, the Lafarge Ecosystems Programme, in the coastal city of Mombasa, Kenya. The paper finds that a well-managed system of green landscapes in resource-poor urban areas can generate net social benefits under a range of future scenarios. It further finds that climate change adaptation and mitigation responses can be initiated by a range of stakeholders operating at all scales.

KEYWORDS climate change adaptation / green infrastructure / mitigation / Mombasa / urban ecosystems / wildscapes

I. INTRODUCTION

As in many parts of the world, most of the existing and proposed adaptive responses to climate change in East African cities are biased towards using "hard engineering" solutions such as building sea walls, levees and channels or relocating infrastructure to control flooding.(1) Such hard infrastructural responses, although necessary in some cases, can present a number of challenges and costs that bring us to question both the effectiveness and efficiency of such solutions relative to the techno-institutional and financial barriers faced by low-income countries. Furthermore, the devastation of New Orleans by Hurricane Katrina in 2005, with the failure of the levee system, demonstrated that hard protection can also fail, with tragic consequences.(2) For low-income countries this emphasizes the need to explore less expensive but multi-beneficial strategies. One such strategy for urban areas is the provision and protection of blocks of contiguous land and improvements in the connectivity of areas of natural resource or ecological value, with the aim of establishing a network of natural areas and working landscapes. This ecosystems approach or "soft

1. Sallema, Rose and G Y S Mtui (2008), "Review. Adaptation technologies and legal instruments to address

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engineering" solution can be achieved through the protection of urban wildscapes and the provision of green spaces, which are viable climate change response options and "no-regrets" measures capable of yielding multiple benefits.

Experiences from around the world tend to show that "soft engineering" solutions to climate change impacts (including the use of ecosystems-based strategies, wetlands and green spaces, green infrastructure and land use planning) are more cost effective and sustainable in the long run than hard technical solutions, and also provide a range of other benefits to society.[3] However, it must be stated from the outset that no single solution or approach is likely to fit all future challenges posed by climate change. For this reason, a toolbox approach from which various treatments and practices can be selected and combined to fit unique situations is generally recommended.[4] In other words, the application of an integrated approach that considers the use of a combination of techno-ecological and social response measures to climate change risks is likely to be a more effective approach.

Given that a combination of technological, financial, institutional and skill constraints, as well as data limitations describing environmental conditions in low-income countries, are likely to limit the implementation and effectiveness of "hard engineering" solutions, there is a need to consider alternative interventions.[5] While promoting urban wildscapes, green spaces and green infrastructure for urban environmental quality and community health is not new, the application of a management approach that accounts for the full values of these urban landscapes in climate change adaptation and mitigation is less widely understood and advocated in the African region, particularly in urbanized areas, and is therefore worthy of further exploration.[6]

The contribution of this paper is two-fold. First, it explores the potential of utilizing the moderating influence of wildscapes and green spaces to address the challenges posed by climate change in Mombasa, Kenya. Second, it presents an example of an innovative and novel approach to urban landscape rehabilitation in Mombasa and draws on lessons learnt from this example to identify the need for improved stewardship of green infrastructure resources to help urban residents in low-income countries adapt to the effects of climate change.

Mombasa is a seaport island city in Kenya, lying within a coastal strip in the hot tropical region that is influenced by the monsoon. Its rapidly increasing population is growing at a rate of 3.6 per cent per annum and now stands at close to one million.[7] Although the scale of climate change risk in Mombasa is yet to be established due to the lack of local analysis, it is expected that climate change will exacerbate current problems such as flooding, storm damage and seashore erosion with serious consequences for infrastructure, coastal assets and human health.[8] Being a harbour city, Mombasa serves as a major conduit of commerce between East and Central Africa and the rest of the world. Furthermore, the city and its surrounding areas account for the biggest proportion of income from tourism, which is also a key driver of Kenya's Vision 2030,[9] and currently accounts for 10 per cent of the Gross Domestic Product (GDP). Therefore, there is a need to explore effective strategies that have the potential to minimize the likely impacts of climate change.

climate change impacts to coastal and marine resources in Tanzania", *African Journal of Science and Technology* Vol 2, No 9, pages 239–248; also Mwandosya, Mark, S B Nyenzi et al. (1998), *The Assessment of Vulnerability and Adaptation to Climate Change Impacts in Tanzania*, The Centre for Energy, Environment, Science and Technology, 234 pages; Dodman, David, Euster Kibona et al. (2009), "Tomorrow is too late: responding to social and climate vulnerability in Dar es Salaam, Tanzania", Case Study prepared for *Cities and Climate Change, Global Reports on Human Settlements 2011*; and Awuor, Cynthia, Victor Orindi et al. (2008), "Climate change and coastal cities: the case of Mombasa, Kenya", *Environment and Urbanization* Vol 20, No 1, April, pages 231–242.

2. Hallegate, Stéphane (2009), "Strategies to adapt to an uncertain climate change", *Global Environmental Change* Vol 19, pages 240–247.

3. ISDR/UNEP (2009), Round Table Discussion on the Role of Ecosystems Management in Climate Change Adaptation and Disaster Risk Management: On the Occasion of the Global Platform for Disaster Risk Reduction, Centre International de Conférences, Geneva, Switzerland, 16–19 June 2007.

4. Millar, C, N Stephenson and S Stephens (2007), "Climate change and forests of the future: managing in the face of uncertainty", *Ecological Applications* Vol 17, No 8, pages 2145–2151.

5. Huq, Saleemul, S Kovats et al. (2007), "Editorial: reducing risks to cities from disasters and climate change", *Environment and Urbanization* Vol 19, No 1, April, pages 3–15; also see reference 2.

6. See reference 3.

7. Republic of Kenya, Ministry of Planning and National Development (2002), *Mombasa District Development Plan*, Government Printer, Nairobi.

8. See reference 5.

II. CONCEPTUAL ISSUES: RELATING THE POTENTIAL FUNCTIONS OF URBAN GREEN LANDSCAPES TO CLIMATE CHANGE CONCEPTS

Landscapes of urban open spaces can exist at different scales, from cracks in the pavement and private backyard gardens to more extensive urban landscapes such as green parklands, woodlands, unused vegetated allotments and abandoned fields. Terms such as wildscapes, green spaces and green infrastructure have been used to highlight the different characteristics of these landscapes.[10] This section begins by giving meaning to these terms. It then discusses their applicability, both as landscapes of open spaces and "no-regrets" strategies, in building resilience (the ability to absorb shock and still maintain functionality) and adaptive capacity (the ability to evolve in order to accommodate change), as well as in adaptation (actions that reduce vulnerability or enhance resilience) and mitigation responses (interventions to reduce the sources or enhance the sinks of greenhouse gases) to climate change.[11]

The phrase "urban wildscapes" has been used to describe those urban spaces where natural processes (as opposed to human intervention) such as the spontaneous growth of vegetation appear to be shaping the land.[12] According to Jorgensen, urban wildscapes often emerge from the aftermath of development. In other words, it is what remains after the programmed uses have ceased. This paper extends the above description to include those spaces where human agency has also contributed to the ecological revitalization of destructed urban spaces to create a new wilderness environment. Urban green spaces on the other hand are heterogeneous structures in size, shape and nature, which can facilitate the survival of some wild species or support biodiversity in the urban habitat.[13] They may include forest patches, parks and other small green areas. Jorgensen cautions that while wildscapes may occur in green spaces they are not necessarily green, as they may also include quarries and expanses of industrial waste.

Well-designed green wildscapes and green spaces constitute green infrastructure, which has been described in the literature as the interconnected system of green spaces that provide natural ecosystem values and services (such as clean air and water and a wide array of benefits to people and wildlife) and is environmentally and economically sustainable.[14] Green infrastructure, such as street trees, parks, green roofs and rehabilitated natural urban waterways, differ from conventional (grey) infrastructure, such as road networks, stormwater pipes and canal systems, in that while the latter is uni-functional (constructed to serve a particular purpose), the former is multi-functional (has multiple benefits).[15]

Adaptation and mitigation are crucial to reducing vulnerability (the degree to which a human or natural system is unable to cope with adverse effects) and thus the overall risk associated with climate change.[16] Hence, the most commonly suggested adaptive option in the climate change context is promoting resilience, perhaps due to the fact that an overarching goal in sustainable development is to create resilient communities.[17] Urban wildscapes and green spaces provide a unique opportunity to address both climate change mitigation and adaptation, in addition to maintaining, restoring and enhancing the natural environment services and offering other socioeconomic functions.[18] They have a crucial role

9. Vision 2030 is a blueprint aimed at transforming the Kenyan economy in order to offer a high quality of life to her citizens. See Republic of Kenya, National Economic and Social Council of Kenya (NESC) (2007), *Kenya Vision 2030*, Government Printer, Nairobi; also Kenya National Bureau of Statistics (KNBS) (2007), "Update on tourism statistics", Government of Kenya, Nairobi.

10. For a detailed description of these terms, see Jorgensen, Anna (editor) (2008), *Urban Wildscapes*, University of Sheffield and Environmental Room Ltd, Sheffield, 80 pages; also Gill, Susannah, J F Handley et al. (2007), "Adapting cities for climate change: the role of green infrastructure", *Built Environment* Vol 33, pages 115–133; Kenney, A (2006), Trees and Green Spaces Working Group Meeting, October 18, in I Wieditz and J Penney (2007), *Climate Change Adaptation Options for Toronto's Urban Forest*, Clean Air Partnership, Toronto, Canada; and Jim, Y C and Y W Chen (2009), "Ecosystems services and valuation of urban forests in China", *Cities* Vol 26, pages 187–194.

11. For detailed descriptions of climate change concepts of mitigation, adaptation, adaptive capacity, vulnerability and resilience, see Folke, Carl (2006), "Resilience: the emergence of a perspective for socio-ecological systems analysis", *Global Environmental Change* Vol 16, pages 253–267; also Adger, Neil W (2006), "Vulnerability", *Global Environmental Change* Vol 16, pages 268–281; Smit, Barry and Johana Wandel (2006), "Adaptation, adaptive capacity and vulnerability", *Global Environmental Change* Vol 16, pages 282–292; Parry, M L, O F Canziani, J P Palutikof, P J van der Linden and C E Hanson (editors) (2007), *Climate Change Impacts 2007: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, pages 141–142; Dodman, David,

to play in response to the impacts of climate change whether through providing temporary holding grounds for stormwater runoff, reducing the risk or extent of flooding, or improving the microclimate of an urban environment. For example, Baines talks of the preference for stormwater to overflow into wild green open spaces rather than into living rooms.[19] As a mitigation option, urban vegetation (including trees and forests) can help to reduce energy flows and ecological "footprints", including the ability to absorb carbon dioxide and some other pollutants from the atmosphere and to cool ambient air through evapotranspiration.[20] This in turn has the potential to lessen the impact of any heat island effect, improving the comfort of microclimates and in turn reducing the demand for air-conditioning in warmer climates (although currently there is little empirical evidence to prove the link to reduced air-conditioning use). The provision of psychological and physical human well-being, free ecosystem services and biodiversity conservation to urban communities constitute other important benefits of urban green landscapes (wildscapes and green spaces) not related to climate change.[21] In general, the use of vegetation cover to reduce the severity of the urban heat island, manage floods and stormwater and provide other recreational benefits is well documented.[22]

To be able to provide multiple benefits, the green landscapes must be resilient enough to accommodate gradual changes associated with climate change and return towards prior condition after disturbance, either naturally or with management assistance.[23] If the green landscapes are themselves vulnerable (e.g. due to loss of ecological functionality), it means that they have lost their resilience, which in turn implies loss of adaptive capacity to respond to future changes in climate. Fundamentally, the formation of interconnected systems of green landscapes and infrastructure is broadly recognized as the optimum approach to protecting or enhancing the resilience of ecosystems and maximizing the return on investment in urban green spaces.[24]

III. GREEN LANDSCAPES IN THE CONTEXT OF MOMBASA

This section outlines the necessity of buttressing the use of urban green landscapes (wildscapes and green spaces), in the context of green infrastructure, as a "no-regrets", "soft engineering" strategy for addressing the effects of climate variability and change in Mombasa. The issues that lend credence to this approach include:

- the lack of technological, institutional and resource capacity (funding and skills) to undertake "hard engineering" options;
- the legal powers and duties of municipal authorities to ensure healthy urban environments;
- current efforts by various stakeholders (including local community groups and private businesses) in tree planting, city beautification and general ecosystems management; and
- the need to have cost-effective infrastructure systems that not only respond to a wide range of climate-related events and extremes but also have multiple benefits to city residents.[25]

Mombasa occupies a low-lying, often flood-prone, coastal location and lacks adequate protection against extreme events. The city is

Jessica Ayers and Saleemul Huq (2009), "Building resilience", in Worldwatch Institute, *2009 State of the World; Into a Warming World*, Chapter 5, pages 151–168; and Adger, Neil (2007), "Assessment of adaptation practices, options, constraints and capacity", in Parry et al. (editors) (2007), see above, pages 717–743.

12. See reference 10, Jorgensen (editor) (2008), page 4.

13. Dwivedi, P, C Rathore and Y Dubey (2009), "Ecological benefits of urban forestry: the case of Kerwa Forest Area (KFA), Bhopal, India", *Applied Geography* Vol 29, No 2, pages 194–200; also Adger, N, N Arnell and E Tomkins (2005), "Successful adaptation to climate change across scales", *Global Environmental Change* Vol 15, No 2, pages 77–86.

14. See González-García, A, J Belliure et al. (2009), "The role of urban green spaces in fauna conservation: the case of iguana *Ctenosaura similis* in the *patios* of León city, Nicaragua", *Biodiversity and Conservation* Vol 18, No 7, pages 1909–1920; also Ahmadi, A and H Golpasha (2008), "Knowledge management in sustainable green infrastructure", International Conference on Information and Knowledge Engineering (IKE), Las Vegas, Nevada, USA, 14–17 July 2008.

15. Commission for Architecture and the Built Environment CABE (2009), "Making the switch from grey to green", CABE Monthly Newsletter, November.

16. See reference 11, Dodman et al. (2009).

17. Dale, Virginia, L A Joyce et al. (2001), "Climate change and forest disturbances", *Bioscience* Vol 52, No 9, pages 723–724; also Spittlehouse, D L and R B Stewart (2003), "Adaptation to climate change in forest management", *BC Journal of Ecosystems and Management* Vol 4, No 1, pages 1–11; see reference 4; and see reference 11, Folke (2006).

18. Rosenzweig, Cynthia, William Solecki and Ronald Slosberg (2006), *Mitigating New York City's Heat Island with Urban Forestry, Living*

characterized by substantial and growing social and environmental problems, including those that are associated with pressures of population growth, housing quality, air pollution and water and sanitation.[26] Climate change is expected to exacerbate these problems, contributing to a heightened risk of flooding, coastal storm damage and seashore erosion, and vulnerability to diseases associated with climatic conditions and land uses, such as malaria and other vector-borne diseases.[27] These will result in costs associated with the loss of infrastructure, biodiversity and natural resource assets (such as fisheries and recreational resources), as well as costs to human health. In addition, socioeconomic factors such as population trends and housing conditions are also changing, altering exposure and sensitivity to flood risks as well as increasing the frequency of flood disasters.[28] Sea level is predicted to rise by 0.1–0.9 metres by 2100, which will aggravate flooding, while it has been estimated that the overall adaptation bill will rise to 10 per cent of the Gross Domestic Product.[29] Yet, the municipal authority has limited assets and capacity to cope with and adapt to the implications of climate change.[30] Therefore, the challenge of urban management in the face of climate change risks points to the need for "no- regrets" and pro-poor interventions.

In Kenya, the Local Government Act, Cap. 265 of the Laws of Kenya gives local authorities regulatory mandates within their areas of jurisdiction.[31] The powers and duties to spearhead local environmental planning and management and to execute local land use planning are critical in shaping the capacity of municipal councils such as Mombasa to roll out urban green infrastructure and, by extension, use the implications of climate change risk as an opportunity to expand (and not necessarily change) their existing mandates.[32] However, in order to use these powers effectively, any such authority requires political will and local support to be able to allocate resources. This means that the full value (whether quantifiable or not) of potential urban green spaces must be recognized, in order to encourage a move away from traditional development of urban land, particularly development that may perpetuate vulnerability to climate change or undermine adaptive capacity.

Many local community groups as well as private businesses are actively involved in city beautification and the planting of trees. For example, the Kenya Forest Services (KFS) facilitates local groups to carry out tree planting. The KFS has formed the Mombasa–Kilindini Community Forest Association (MKCFA) to undertake participatory urban forest management. The business sector in Mombasa is also involved in tree planting and ecosystem management, generally contributing to the environment as corporate citizens. Such companies include Mabati Rolling Mills, Bamburi Cement Factory, Athi River Mining and Kenya Pipeline. As an example, the Kenya Ports Authority (KPA) recently sponsored the rehabilitation of Mama Ngina Park, located in the city centre.[33] In addition, during this study, resident groups in Port Reitz, Tudor and Mtongwe in Mombasa (Figure 1) were found to be involved in mangrove regeneration, in part because residents have a sense of responsibility to care for the environment, but also as a source of livelihood. For example, a youth group working on the mangroves along the Mtwapa creek, which is in Kilifi district but close to Bamburi in Mombasa (Figure 1), has devised methods to obtain benefits from the mangrove forests through "silvofisheries",[34] while at the same time ensuring conservation and further regeneration of the mangroves.

Roofs and Light Surfaces. Final Report: New York City Regional Heat Island Initiative, prepared for the New York State Energy Research and Development Authority (NYSERDA), New York, 133 pages.

19. Baines, C (2008), "The wild side of town", in Jorgensen (editor) (2008), see reference 10, pages 10–11.

20. Chambers, N, C Simmons and M Wackernagel (2000), *Sharing Nature's Interest: Ecological Footprints as an Indicator of Sustainability*, Earthscan Publications, London, 200 pages; also see reference 10, Kenney (2006); and see reference 10, Wieditz and Penney (2007).

21. See reference 13, Dwivedi et al. (2009).

22. See Rosenfield, A H, H Akbari et al. (1995), "Mitigation of urban heat islands. Materials, utility programmes, updates", *Energy and Buildings* Vol 22, pages 255–265; also Corburn, Jason (2009), "Cities, climate change and urban heat island mitigation: localizing global environmental science", *Urban Studies* Vol 46, page 413; Heisler, G, S Grimmond et al. (1994), "Investigation of the influence of Chicago's urban forests on wind and air temperature within residential neighbourhoods", Nen. Tech. Rep. NE-186, USDA Forest Service, Washington DC; Taha, H, S Konopacki and S Gaberseck (1996), "Modelling the meteorological and energy effects of urban heat islands and their mitigation. A 10-region study", Lawrence Berkeley National Laboratory Report LBL 39298, Berkeley CA; McPherson, E G, J R Simpson et al. (2005), "Municipal forest benefits and costs in five US cities", *Journal of Forestry* Vol 103, No 8, pages 411–416; Solecki, W D (2005), "Mitigation of the heat island effect in urban New Jersey", *Global Environmental Change Part B: Environmental Hazards* Vol 6, No 1, pages 51–62; and Santamouris, M, K Pavlou et al. (2007), "Recent progress on passive cooling techniques: advanced technological development to improve survivability levels in low-income households", *Energy*

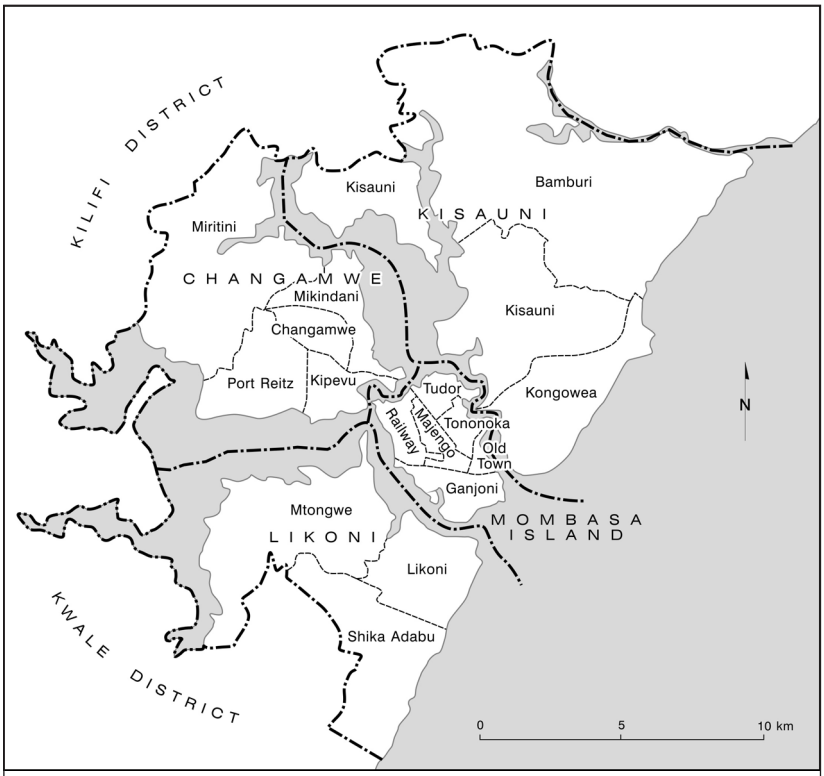

FIGURE 1
Map of Mombasa Island and surrounding areas

SOURCE: Adapted from a map drawn by the author.

Thus, if well supported, a range of different stakeholders in cities such as Mombasa can facilitate the establishment of cost-effective, citywide green infrastructure systems through urban greening. Furthermore, given the recent occurrences of flooding, wind destruction and increased average temperatures that have exposed the vulnerability of Mombasa to the impacts of climate change, the challenge facing the municipal authority is to try and establish a system of land use management for open green landscapes to help buffer floods, provide natural stormwater management, reduce energy use (through shading and/or evapotranspiration), as well as reduce costs associated with engineered systems.[35]

a. From wildscape to greenscape: Mombasa's Haller Park

This section describes an innovative urban landscape management activity in Mombasa that involves the transformation of a wildscape (as defined by Jorgensen[36]) into a thriving urban wilderness. This particular example is not intended to provide proof of how the rehabilitation of the wildscape into a thriving ecosystem has helped in responding to climate change risks in Mombasa; rather, it is a demonstration of how a key

and Buildings Vol 39, No 7, pages 859–866.

23. See reference 17, Spittlehouse and Stewart (2003).

24. See reference 14.

25. See reference 2; also see reference 3; The Municipal Council of Mombasa (2008), "Environmental management bye-laws", *Laws of Kenya* (Cap. 265), Mombasa; Kenya Law Reports (1964), *Laws of Kenya,* accessed 2 October 2009 at www.kenyalaw.org; and Kenya Forest Services (2008), "Coast province", unpublished report, Mombasa.

26. See reference 7.

27. Boko, M, I Niang et al. (2007), "Africa", in Parry et al. (editors) (2007), see reference 11, pages 433–467; also see reference 11, Parry et al. (editors) (2007), pages141–142.

28. See reference 1, Awuor et al. (2008).

29. See reference 1, Dodman et al. (2009); also Hulme, M, R Doherty et al. (2001), "African climate change: 1900–2100", *Climate Research* Vol 17, pages 145–168.

30. Kithiia, Justus and Robyn Dowling (2010), "An integrated city-level planning process to address the impacts of climate change in Kenya: the case of Mombasa", *Cities*, Vol 27, No 6, pages 466–475; also Tanner, T and T Mitchell (2008), "Introduction: building the case for pro-poor adaptation", *IDS Bulletin* Vol 39, No 4, pages 1–5.

31. See reference 25, Kenya Law Reports (1964).

32. Hagerman, S, H Dowlatabadi et al. (2010), "Expert views on biodiversity conservation in an era of climate change", *Global Environmental Change* Vol 20, No 1, pages 192–207.

33. See reference 25, Kenya Forest Services (2008).

34. Silvofisheries refer to integrated mangrove–fish/shrimp farming. The youth group protects the forest from destruction through continuous surveillance. There have been newspaper reports that the group has shattered the long-held myth that mangrove trees can only grow naturally

by establishing nurseries of appropriate mangrove species.

35. *Nation News* (2008), "Man dies as heavy rain pounds coast", June; also MacClanahan, Tim (2007), "Achieving sustainability in East Africa coral reefs", *Journal of Marine Science and Environment* (C5), pages 1–4.

36. See reference 10, Jorgensen (editor) (2008).

37. Haller, René and S Baer (1994), *From Wasteland to Paradise: A Breathtaking Success Story of a Unique Ecological Experiment on the Kenya Coast*, Hans H Koschany Verlag, Germany, 119 pages.

stakeholder has engaged in successful urban ecosystem management that may have consequences for climate change adaptation and mitigation among other socio-ecological and economic benefits. Furthermore, it is used as a basis for the argument that facilitating the expansion of such initiatives through planning and management can lead to the attainment of a citywide green infrastructure system, with its associated benefits.

In 1952, Cementia Holding AG, Zurich was looking for a suitable site on the East African coast on which to build a cement factory. The choice of location depended on three requirements: limestone and shale (the main materials necessary to manufacture cement) had to be obtainable within the vicinity of the plant; the factory had to be near a harbour for export purposes; and it also had to be close to a railway line for inland sales. At the time, there was an area of uninhabited bushland a few kilometres north of Mombasa that was ideal for the project, and it was here that the company built the Bamburi Cement Factory. The resulting excavation of coral for cement manufacture turned a two-square kilometre area into an inhospitable arid wasteland, which expanded annually by tens of thousands of square metres.[37] Many years later, in 1990, the French multinational (Lafarge Group) purchased a 60 per cent stake in Cementia Holding AG, and among the properties purchased were cement plants and transportation terminals, including the Bamburi Cement Factory.

i. History: quarry to park

Bamburi Cement Factory, now a subsidiary of the French multinational Lafarge Group, is located in the Kisauni area of Mombasa (Figure 2).

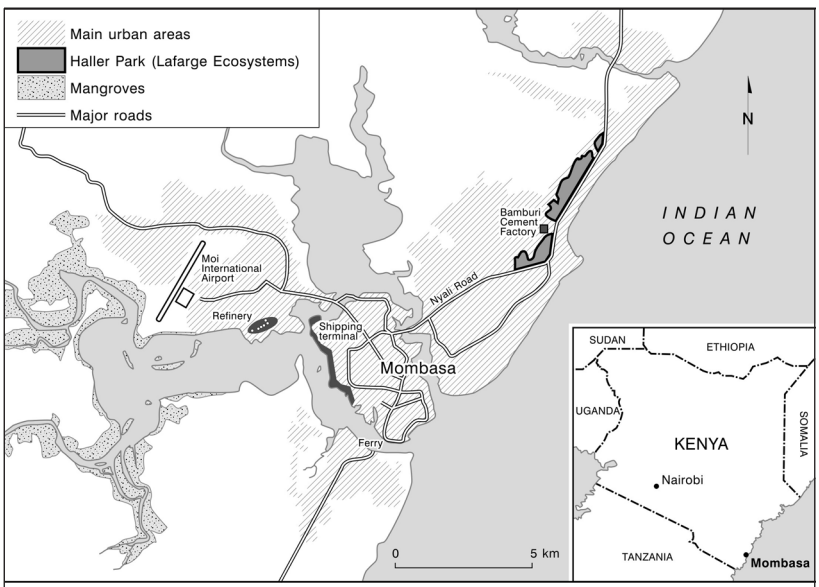

FIGURE 2
Map of Mombasa showing the location of Lafarge Ecosystems

SOURCE: Adapted from a map drawn by the author.

Through the Lafarge Ecosystems Programme, the company has become world famous for its rehabilitation of quarry mines. The Mombasa rehabilitation programme, initially called the Bamburi Quarry Nature Park and now renamed Haller Park, was initiated in 1972.[38] The mines formed wildscape areas, which had been left when quarried materials were taken away for cement manufacture, leaving an inhospitable wasteland. Although north Mombasa benefited from the location of the cement factory (particularly through the creation of employment), the large area of bushland was converted into a wasteland that expanded every year by tens of thousands of square metres. At the time operations commenced, no environmental law required mining industries in Kenya to rehabilitate exploited land. However, the management of the cement factory felt it had a responsibility to do so long before the subject of environmental protection became a worldwide issue.[39] After many attempts to find pioneer plants that could survive in the limestone desert, Casuarina equisetifolia, or whistling pine (a tree that originates in Australia and is adapted to grow under severe conditions), seemed to be ideal for the harsh environment. After a few years of planting, the casuarinas became self-seeding and began to colonize the surrounding quarry. Over time, these pioneer trees improved the soil condition, allowing new plant species to become established, including indigenous species. To improve biodiversity, a limited number of wild animals were introduced at various stages, while birds and insects found their way into the forest.[40] After about 25 years, the former quarry has become forested and ecologically and economically self-sustaining. Photo 1 shows a section of the park as it appears today.

38. Haller Park is named in honour of René Haller, a former employee of the cement company, who is credited with initiating the rehabilitation project.

39. See reference 37.

40. See reference 37 for a more detailed account of the sequential development of Haller Park.

ii. Current status

The company has 250 hectares of mined land, of which 220 hectares have been rehabilitated. Currently, Haller Park is home to 400 different varieties of indigenous trees, including bushes and herbs; also 230 species of birds, some of which have been classified by the International Conservation Union (IUCN) as endangered species; and mammals, reptiles and small cats (including giraffe, waterbuck, hippopotamus, eland, oryx, buffalo and crocodile). In addition, a large number of insects have been observed in the forest, ensuring a diversity of life, with every species making a unique contribution. The result has been the creation of a wilderness park in the city, bringing Mombasa residents into contact with nature, providing socio-psychological benefits, and promoting both educational and recreational activities. Observing the number of people visiting the park, especially at weekends and on public holidays, the eco-tourism value is also evident. According to official records the park receives about 150,000 visitors per year. The value of the park was captured by one Mombasa resident during a visit: "*Since I do not enjoy going to the beach, on hot days when I'm not at work I come here to do some bushwalking. I find it cooler… and there is fresh air.*" Most afternoons, residents can be seen whiling away time along the Mombasa–Kilifi road, under the shade provided by trees in the park (Figure 2).

Haller Park is also demonstrating other social, educational and economic benefits to the wider community. For example, a Kenya Forest

PHOTO 1
An area of Haller Park

© Justus Kithiia (2009)

Service (KFS) official in Mombasa explained that his department had been organizing local user group members to visit the park for training and demonstrations on effective tree management. Community groups are sub-contracted to undertake rehabilitation works, especially the replanting of trees, thus helping them to "learn by doing"; and the Lafarge Ecosystems Programme is also represented in the Integrated Coastal Zone Management Programme. In terms of socioeconomic benefits, a local community group that makes and sells curios and other artifacts has entered into partnership with the park's management to sell its merchandise for better returns. Similarly, a long-term community resident attributes the emergence of big business in the area to the existence of the park (according to him, property values in North Coast, the location of Haller Park, have quadrupled in the last 15 years).[41]

41. Personal communication (2009) from a local resident who has lived in North Coast for the last 25 years.

IV. DISCUSSING THE LAFARGE ECOSYSTEMS PROGAMME AND RELATED ACTIVITIES IN THE CONTEXT OF CLIMATE CHANGE RISK RESPONSE AND OTHER SOCIO-ECOLOGICAL BENEFITS

The ensuing discussion revolves around four recurring themes, namely, mitigation, adaptation, local sustainable development and socioeconomic benefits. These could be viewed as signifying both the actual and the potential contribution of the Lafarge Ecosystems Programme and related activities to the city of Mombasa amidst the likely impacts of climate change.

It is clear from the history of the Lafarge Ecosystems Programme that responding to climate change was not one of the original objectives of rehabilitation 25 years ago. This is not surprising since, at the time, climate change was not a prominent issue in the development agenda generally. To date, there is no evidence to suggest that current knowledge of the implications of climate change has caused a rethink of the value of greening urban environments through rehabilitation, instead climate change has become yet another lens through which the value of rehabilitation projects, such as the Lafarge Ecosystems Programme, can be considered. This can be inferred from the following statement by the Lafarge Ecosystems manager during an interview in 2009:

> "Lafarge has a responsibility to rehabilitate all their mines in over 74 countries. It's a moral decision to give back to nature as we extract limestone for cement. However, as the Haller Park project in Mombasa has grown bigger than was initially anticipated, we have now decided to grow more trees [for the offset of greenhouse gas emissions] with the intention of substituting coal energy with renewable energy. This will not only reduce our production costs but is also good for the environment."

It has been stated that irrespective of the motivation for climate change adaptation, both purposeful and unintentional adaptation can generate short- and long-term benefits.[42] Haller Park as a well-maintained ecosystem has the potential to create adaptation co-benefits despite this not being the original intent. The trial and error methods initially used by the rehabilitation team to identify and establish the pioneer plants is recognized by Agrawal as a critical approach in identifying effective adaptation options, especially for a resource-poor city like Mombasa.[43] He further asserts that an adaptive perspective on development will require a willingness to experiment, the capacity to take the risk of making mistakes, and the flexibility to make space for social and institutional learning.

The local corporation (Bamburi Cement Factory) may be unaware of its role both as a driver and responder to climate change. However, its involvement in corporate social response shows an understanding of how context shapes socio-ecological interactions within the city, hence its potential contribution to building resilience to climate change impacts.[44] Furthermore, for a resource-poor city like Mombasa, where the state of knowledge about the most effective ways in which institutions can facilitate local climate change risk responses is sparse and where no blueprints exist for planning such responses, the municipal government cannot be expected to be the main stakeholder in spearheading climate responsive measures. The Lafarge Ecosystems Programme demonstrates an alternative role for municipal authorities, that is, one of facilitator of specific opportunities and sustainable initiatives, which initiatives may be implemented by a range of stakeholders (including local communities, private corporations or other opportunistic partnerships between different agencies). However, given the generally low priority given to climate change issues in Mombasa, coupled with ineffective urban governance in Kenya in general, it may take further incentives or other agencies to encourage the take up of such "value-adding" initiatives.[45] This, however, does not negate the fact that the Lafarge Ecosystems Programme could serve as an indication of how climate change response actions can cascade across a landscape and be initiated by agents ranging from individuals to corporations and public bodies as well as governments.

42. See reference 13, Adger et al. (2005).

43. Agrawal, A (2008), "The role of local institutions in adaptation to climate change", Paper prepared for Social Dimensions of Climate Change, Social Development Department, World Bank, Washington DC.

44. While corporate social responsibility is punctuated with legalisms and a notion of fixed obligations, corporate social response is a much more open concept.

45. See Taylor, Wendy and Tom Goodfellow (2009), "Urban poverty and vulnerability in Kenya", Briefing Note, Oxfam GB, 10 September.

Due to its tropical location, Mombasa can be very hot, averaging 65 per cent humidity and 32°C heat.[46] The fact that some people visit Haller Park on hot afternoons to experience its cool temperatures shows the potential of urban green landscapes in alleviating outdoor thermal discomfort in the urban environment. While the likely extent of changes to ambient temperature due to climate change is uncertain for East Africa, the chapter on Africa in the IPCC Fourth Assessment Report notes limited increases in temperatures in the tropics compared to other latitudes based on global warming models; similarly, the chapter alerts us to the combined impact of local land use change, land clearing and deforestation on micro-climates and thereby an increase in local temperatures in regions such as East Africa.[47] An increase in ambient temperature due to these combined effects could potentially increase mortality among the urban poor and vulnerable populations who tend to lack the economic means and social support systems necessary to avoid the adverse health impacts associated with extreme temperatures.[48] However, as is characteristic of most benefits of urban green landscapes, a citywide effect in reducing thermal discomfort and air pollution is only achievable in the presence of well-designed systems of green spaces and green infrastructure, and not just isolated green landscapes such as the Haller Park.[49]

To the local community, the park also provides an opportunity to be close to nature, with the associated positive impacts that this can bring in terms of mental health and the simple pleasure of experiencing trees, birds and other wildlife in an urban situation. This is apparent in the high number of people who visit the park each year. By involving the community in its activities through local partnerships, the Lafarge Ecosystems Programme adds to the broader social dimension that has the potential to facilitate adaptive ecosystem management. Indeed, this may help to create social networks, which could serve as the web that ties together an effective adaptive governance framework.[50] The Lafarge Ecosystems Programme seems to lay emphasis on an ecological and economic basis for rehabilitation rather than on socio-ecological considerations. In order to enhance the value of such initiatives and provide long-lasting social, educational and adaptive benefits, it is necessary for the planning, design and management of such programmes to have an understanding of how residents interact, value and understand the environment, rather than just support planting and maintenance of vegetation. Furthermore, where opportunities occur on private property, it may also become necessary to engage private landowners.

In the face of climate change, a major shortcoming of a rehabilitation initiative such as the Lafarge Ecosystems Programme is the trial and error methods used by the rehabilitation team to identify and establish pioneer plants. This approach risks the introduction of invasive species, thus creating green spaces that are ill-adapted and susceptible to undesirable changes.[51] On the other hand, the emphasis put on the adoption of local materials and species by the rehabilitation team (such as the use of indigenous plants) may at times prove to be ill-advised. This practice is likely to consign the whole greening project to what Harris et al.[52] refer to as a generic "dead end", which does not allow for the rapid adaptation to changed circumstances that may be necessary if climate scenarios proceed as predicted. Therefore, into the future, it will be necessary to ensure a balance between rehabilitation through the introduction of plant species and the need to build resilient green landscapes. Thus, rehabilitation

46. See reference 7.

47. See reference 27, where Boko et al. have discussed climate change impacts, adaptation and vulnerability in the African context.

48. Klinenberg, Eric (2002), *Heat Waves: A Social Autopsy of Disaster in Chicago*, University of Chicago Press, 328 pages.

49. Hertberg, Rasmus, P Siegel et al. (2009), "Addressing human vulnerability to climate change. Toward a 'no-regrets' approach", *Global Environmental Change* Vol 19, pages 89–99; also see reference 11, Folke (2006).

50. See Olsson, Per, C Folke and T Hahn (2004), "Adaptive co-management for building resilience in socio-ecological systems", *Environmental Management* Vol 34, pages 75–90.

51. Millar et al. (2007) discuss some of the undesirable consequences of urban greening; see reference 4.

52. Harris, J, R Hobbs et al. (2006), "Ecological restoration and global climate change", *Restoration Ecology* Vol 14, No 2, pages 170–176.

through the lens of climate change requires thinking about future climatic possibilities and conditions in order to plan and design for more resilient ecosystems. In Australia this approach has been recognized and adopted by landscape architects and land managers, where careful consideration of the use of various plant species is recommended, for example the use of drought-hardy species in regions where water is scarce or is likely to become less reliable.[53]

A visit to Haller Park shows that the Lafarge Ecosystems Programme has invested heavily in water sources and recycling to irrigate and maintain the tropical vegetation. This approach may not be sustainable in the longer term under climatic change. According to a Mombasa Water and Sanitation Company engineer, the city currently only receives 45 per cent of the water required for normal use.[54] Although rainfall along the coast of East Africa is predicted to increase by 30–50 per cent due to climate change, it is also expected to be more variable, making it more difficult to rely on rainfall to provide the water needs for urban vegetation.[55] This presents a big challenge in initiating and expanding green infrastructure not only in Mombasa but also in other poorly resourced urban centres.

Although Bamburi Cement Factory, through the Lafarge Ecosystems Programme, has demonstrated the possibility of achieving well-maintained green landscapes in Mombasa, the municipal authority has yet to supply the frameworks for the provision of quality control. This could be attributed to the institutional fragmentation of the planning systems in Kenya in general, which makes it difficult to adopt local planning frameworks within which the importance of green infrastructure can be addressed. Notwithstanding the resource deficiency of the local authority, with more effective planning, existing funding and skill capacities can be better tailored towards value-adding development, promoting best practice such as green infrastructure-based projects.[56] The municipal authority's regulatory mandate to control development in its area of jurisdiction can help leverage local policies to facilitate the expansion of green landscapes. These might include providing incentives for resident groups and private individuals to plant and care for trees and green spaces, formulating bye-laws to regulate or encourage green landscaping, identifying opportunities for developing a system of green spaces and green infrastructure in the medium to longer term via strategic planning, and embracing adaptive city governance approaches.

53. This has been pointed out in Lyth, A, S Nichols and D Tilbury (2007), "Shifting towards sustainability: education for climate change adaptation in the built environment sector", Report prepared by the Australian Research Institute in Education for Sustainability (ARIES) for the Australian Department of Environment and Water Resources, 53 pages.

54. Personal communication from a Mombasa Water and Sanitation Company engineer (2008).

55. Intergovernmental Panel on Climate Change IPCC (2001), *Climate Change 2001: Impacts, Adaptation and Vulnerability*, Cambridge University Press; also see reference 27.

56. Both the Mombasa District Development Plan (2002) (see reference 7) and the Oxfam Briefing Note by Taylor and Goodfellow (2009) (see reference 45) are useful in understanding the state of urban planning in Kenya.

V. CONCLUSIONS

The multi-functional nature of urban green infrastructure consisting of wildscapes and green spaces necessitates the application of management approaches that account for the full value of these urban landscapes. This is especially so in the face of predicted changes in future climate and parallel pressures of land use development and change. For low-income countries, the implications of climate change create a new urgency to seek ways of building general resilience through cost effective "no-regrets" interventions. Pursuing adaptive governance in poorly resourced urban areas requires that efforts be directed towards green infrastructure as opposed to expensive grey infrastructure development, for the simple reason that well-planned systems of green landscapes have the potential to generate net social and ecological benefits under a range of future

scenarios. It is, however, important to keep in mind that no single approach fits all future challenges posed by climate change. For this reason, adaptation responses will need to come from a range of treatments and practices, selected and combined to fit unique situations.

The Lafarge Ecosystems Programme and related activities show that the development of green landscapes may involve voluntary actions by various stakeholders in the city. Although the municipal authorities have the overall mandate to provide frameworks for quality control and ensure systematic planning of green landscapes, stakeholder involvement can ease the burden of implementation from the frequently cash-starved authorities. To ensure full cooperation from businesses and corporations, which are not only major responders but also drivers of climate change, their involvement should be viewed as a social **response** rather than a social **responsibility**. The synergies necessary in addressing the uncertainties surrounding climate change require that corporations, governing authorities and other players do not get stuck in the legalities of social responsibility. What is required is a framework that relies on collaborations of a diverse set of stakeholders in the city as well as approaches that embrace flexibility, learning from experience and continuous incorporation of lessons into future plans. In addition, plans should be informed by the fact that even the most elaborate green infrastructure will only have a certain range of adaptive capacity; hence the need to base greening decisions on a knowledge of socio-ecological resilience.

The "no-regrets" interventions are not cost free and therefore expanding the green landscapes will attract both direct and indirect costs. This is especially so in Mombasa and other cities in low-income countries, where the built form does not normally allow for significant sites for the establishment of green spaces for public or ecological good. A major task for planners and decision makers will therefore be to ensure both innovation and cost effectiveness; for example, by optimizing scarce resource investments and identifying initiatives that are implementable by a range of stakeholders.

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