



Exploring the potential of nature-based solutions in informal settlements upgrading: a transformative approach for Sub-Saharan Africa



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This perspective examines the inclusive design and planning processes to implement nature-based solutions (NbS) in informal settlements of Sub-Saharan Africa, comparing a case study in Kigali, Rwanda with other approaches in the region. In these settings, existing socio-ecological infrastructure and less distinctive boundaries between urban and natural systems create opportunities for networks of micro-projects to gain traction. The paper discusses a framework of participatory design for network-based NbS interventions to enhance their uptake and expand strategic implementation over time using capacities available in these contexts.

In the last few years, a dialogue around theoretical constructs promoting Nature-based Solutions (NbS) in informal settlements has taken hold, purporting to offer integrated approaches which address the complex interplay of environmental, social, and economic issues that characterize these vulnerable communities. By integrating natural elements and ecosystem-services approaches into the upgrading, design, and development of informal settlements, NbS certainly has potential to provide a multitude of benefits, including (but not limited to) improved ecosystem services^{1,2}, enhanced urban cooling and air quality^{3,4}, increased food security through urban agriculture⁵, and the creation of green spaces that foster community cohesion and perceived well-being^{6,7}.

Whether NbS has lived up to its newfound hype is debatable, regardless of its latent potential. Perhaps more important than initiating this debate, though, is the recognition that there is no single frame within which such a discussion can take place, and that the vantage points from which dialogues around NbS can be utilized in Global South contexts is incomplete.

How we got here: the North-South migration of NbS

First coined in the subtitle title of a 2008 World Bank report, Nature-based Solutions as a set of strategies was initially left undefined and open to interpretation. The body text of that document does not actually use the term ‘nature-based solutions’; rather, it refers to “nature-based livelihood options,” “nature-based adaptation,” and “nature-based tourism”⁸, demonstrating a strong inclination towards marketable actions. Shortly thereafter, a position paper from the International Union for the Conservation of Nature (IUCN) proposed formally adopting NbS as an “integral part of broader adaptation and mitigation plans and strategies”⁹, implying a more climate-risk and ecological management-based focus, but still leaving

NbS without a clear definition. It would be more than a decade before a multilaterally agreed definition of NbS as “*actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits*”¹⁰ would appear, though various unilateral definitions had been developed in the time between, most prominently by the European Commission (EC)¹¹ and IUCN¹². A more specific focus on “cost-effective” solutions which “simultaneously provide environmental, social and economic benefits” – part of the definition proposed by the EC – more explicitly opens the door to thinking about green infrastructure, thereby becoming more obviously applicable to urban areas¹³, as opposed conservation efforts.

In 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services started issuing several calls for transformation around climate change approaches and NbS¹⁴, calling for a system-wide reorganization across technological, economic, and social factors, highlighting this transformation as a crucial strategy for devising effective responses to climate change. However, the initial framing of NbS, with its strong emphasis on voluntary carbon market mechanisms to offset private-sector emissions¹⁵, coupled with the overall dominance of Global North researchers and practitioners in conceptualizing frameworks for implementation^{15–17} has raised concerns about its potential to perpetuate the very worldviews and power structures that have contributed to the climate crisis.

The commodification of land for ‘preservation’ and carbon offsets being taken from financially impotent indigenous communities¹⁸, often in richly biodiverse areas (which, ironically, tend to be places where human

and natural systems are already more harmonious than they are in the urban areas of the Global North)^{19–21} is problematic, but examining NbS through this lens alone is of limited utility in urban areas, where vast swathes of territory for these purposes is unavailable. Given that a significant portion of urban expansion in the coming years is expected to occur in cities of the Global South, it is important to explore how NbS can be impactfully (and justly) applied in urban settings there, and whether similar inequities are perpetrated or even promoted (albeit inadvertently). In the context of rapidly urbanizing sub-Saharan Africa, where development policy trends often (inappropriately, in many cases) aim to replicate the approaches of more affluent cities in the Global North²², but where informal settlements are disproportionately vulnerable to climate impacts, there is a need to re-examine the transformative potential of NbS through a more inclusive, equitable, and applicable lens.

Charting a course: questions of implementation of NbS in informal settlements

Conceptually, NbS dangles tantalizing prospects in front of sub-Saharan African cities. The chance to mitigate climate risks, provision basic infrastructure to informal settlements disproportionately susceptible to climate risks, and reduce upfront implementation costs, all while yielding positive ecological outcomes and providing much-overlooked public space for urban residents is obviously appealing. Add to that the restoration of a wide range of habitats across landscapes critical to biodiversity²³ (one of the initially stated aims of NbS and a major component of the concept of Planetary Boundaries²⁴), and the quest to implement NbS sounds like a no-brainer. But, being a nascent field, evidence of successful interventions and implementation strategies in sub-Saharan Africa has not fully materialized.

There is growing consensus that NbS must be designed, implemented, and monitored by (or with substantial input from) local communities²⁵. Clear pathways to achieve this, however, often remain elusive. Currently, an outsized portion of the knowledge and literature around NbS springs from the Global North, while an understanding of the barriers, opportunities, and engagement methods for NbS in historically disadvantaged areas of the Global South is limited^{15,25}.

Thus, while NbS is a potentially important part of the upgrading process^{15,26}, there is a mismatch of knowledge and theory (largely formulated in the Global North) with on-the-ground needs in areas where over a billion people globally live—238 million of them in sub-Saharan Africa²⁷. This paper aims to make small strides towards reducing this mismatch. It explores a framework of participatory design drawing upon local and traditional knowledge to enhance NbS, potentially generating self-propelling lessons and revealing more navigable pathway towards effective implementation.

Critiquing NbS frameworks

Framing the NbS narrative: ecosystem service or colonial distraction?

From the outset, the NbS concept was tied to concepts of natural capital, valuation of ecosystem services, and marketable strategies, presumably to gain private sector buy-in²⁸ and help to attract both public and private financing. Consistent with common historical Global North views of urbanization being separate from, or even in competition with, natural systems^{22,29}, the heavy emphasis on capital (whether financial or natural) risks perpetuating, or even exacerbating, the worldviews, values, and power structures that have contributed to climate change and inequalities^{13,18,30}, marginalizing capital-light communities such as those residing in informal settlements of the Global South. Attempting to resolve this by propelling a sort of “commodity fetishism”³¹ of nature simply brings conceptions of nature into an anthropocentric way of thinking, raising concerns about both the transformative potential and redistributive justice possibilities which NbS could offer. Critics also raise the alarm about the potential for local communities to be sidelined, particularly through well-funded efforts to deliver large scopes of NbS interventions^{13,23,32}, stripping them of agency in the name of mitigating climate change.

Agency power allows agents (whomever they may be) to identify and frame societal issues as political ones, and allocate resources towards the most desirable solutions^{33,34}. Framing what is ‘desirable’ depends on what the end goal is; if we take the framing of NbS as a form of climate change mitigation service, ‘desirability’ would essentially be the absolution of responsibility for contributing factors of climate change by offsetting the damage elsewhere. This is hardly an aspirational goal, and certainly not one that is primarily focused on the upliftment of urban communities in the Global South, or the regeneration and repair of interlinked human-nature systems. Stemming from this, much of the dialogue around NbS—at least initially—held anthropocentrism as an implicit value and emphasized the perception of nature as a resource to be exploited^{35,36}, all but ignoring inclusiveness or the fostering of transformative change³⁰. The danger here is that NbS becomes little more than a slogan of eco-modernism and ‘green growth’, but which does not fundamentally affect changes needed to respond to the climate crisis³⁷ it was purportedly set up to achieve.

The focus on climate change, though certainly relevant, is limiting, reducing NbS to a transactional process of implementing solutions in one location as a means of offsetting activities in another, potentially making NbS a “dangerous distraction”³⁰ from real issues of decarbonization. In this form, sites are seen essentially as ‘banks’ which produce a sort of carbon abatement capital, which can then be spent freely, forgoing the need for systemic change. The idea of global climate change mitigation is not wrong, per se, though given the scale of the problem, achieving mitigation targets through NbS alone is not especially realistic¹⁸. More importantly to cities in the Global South, though, the global focus raises questions as to the value physical interventions add to local residents’ lives, if the accounting used to justify NbS remains a global one.

In the immediately foreseeable future, the Global South will bear the brunt of climate risks, and informal settlements in Global South cities often bear these risks doubly so: their vulnerability to real disasters, often induced or exacerbated by climate change and already manifesting^{38,39}, is compounded by the risk that the ‘solutions’ proposed to be implemented in their backyards are in service not of urgently pragmatic problem-solving on the ground, but of global efforts to give major contributors to climate change a ‘way out’ of the carbon dilemma, thus perpetuating a form of colonial thinking about the issues⁴⁰.

It should be self-evident that if we are to speak of nature-based ‘solutions,’ then real solutions should actually be present for the recipients of such interventions. A transactional approach to NbS does not necessarily consider local relevance and genuine, impactful problem-solving at intervention sites themselves as part of the equation. In response to these risks, recent IUCN guidelines for the implementation of NbS place consideration of communities’ rights ahead of natural resources⁴¹, but if the intended purpose of NbS remains the mitigation of climate change at a global level, there is a fundamental contradiction of aims. While proponents of a “vulnerability narrative” of NbS do stress the need to focus on benefits to local communities over a more abstract public good¹³, these ought not be mutually exclusive objectives.

Lost in translation: the inability to replicate NbS implementation methods from North to South

Differences between the implementation of NbS in the Global North and Global South are potentially vast.

One stream of inquiry in the literature around NbS is on improving mechanisms for land- and water-based practice or infrastructure implementation³⁶, consistent with the idea of NbS as green infrastructure performing ecosystem services. But herein lies a key difference between the means of developing, designing, and implementing NbS in the Global North and Global South: unlike in most of the Global North, ‘infrastructure implementation’ in Global South cities, and in informal settlements in particular, is rarely done through formal means, executed by governmental authorities and funded through public coffers. Attempts by sub-Saharan African cities to play ‘catch up’ with increasing demands for urban systems has often been driven by top-down masterplanning, mirroring the

development methods inherited from colonial powers, which were already inadequate in the Global South and which have accentuated many of the challenges faced by sub-Saharan African urbanism today⁴². Though regimes and knowledges have evolved, and newfound interest in the influence of indigenous knowledges on urbanism is taking shape^{43,44}, formal planning regimes – and especially urban design frameworks – remain wanting in many sub-Saharan African cities⁴⁵.

Where more formal methods of design and development have failed, or at least been unable to sufficiently address key challenges, “creative planning” and community-based approaches to managing urbanism have evolved somewhat organically—often out of necessity—with concepts of green infrastructure starting to come to the fore⁴⁵. Socio-ecological infrastructure⁴⁶ often makes up for, or at least attempts to make up for, a lack of formal infrastructure.

In fact, taken from the standpoint of a historical relation of humans’ dependence on ecosystem services, referring to ‘Nature-based Solutions’ is a just another way of framing bottom-up practices which have been employed in sub-Saharan Africa and many non-Western cultures for centuries. It has perhaps taken on new meaning in the current era of urbanization, but because localized effects of the Great Acceleration⁴⁷—for better or worse—came later to sub-Saharan Africa than the Global North, worldviews across much of the sub-continent were never fully severed from indigenous knowledges more attuned to the human-nature interdependency, despite the overwhelming scholarship bias towards the Global North^{48–51}.

To at least some extent, though not necessarily in intentionally planned ways, the ontologies of an interconnected human-nature worldview, coupled with the limited provisioning of hard infrastructure that is common in sub-Saharan Africa, are reflected in the urban form and governance. Many sub-Saharan African cities retain significant remnants of native ecosystems, providing important regulating and provisioning services which are less prevalent in urban areas of the Global North. The rapid and complex patterns of urbanization in Africa result in less distinct urban-rural boundaries, with natural elements integrated throughout the urban fabric, rather than concentrated in discrete green spaces⁴⁵. Urban agriculture and harvesting of wild foods and goods are important for livelihoods and food security, especially for the urban poor; these provisioning services act as “safety nets” and are more prevalent in sub-Saharan African cities⁴⁵. Even today, separation between urban environments and natural conditions in these locations tends to be less distinct than in the Global North⁴⁹, with connections to traditional knowledge systems rooted in worldviews which recognize interconnectedness and hold natural functions as more than just resources, but as part of a value system. This suggests that NbS approaches that engage with different types of knowledges, acknowledge a broad range of values, and are inclusive of a variety of worldviews are more likely to be incorporated into policy and practice, and more likely to facilitate transformative change.

Reframing ‘projects’ as ‘networks’

The commodification of NbS almost inherently requires implementation to be thought of as ‘projects’ which yield investment returns (either monetary or in the form of carbon credits, flood mitigation, etc.). When emphasis is placed on natural capital and quantifiable ecosystem services, there is an inherent risk of tying policymaking to technical or managerial decision-making processes⁵¹.

It is important here to define what is meant by a ‘project-based’ approach. NbS ‘projects,’ in this context, are planned, funded works, typically implemented through public authorities (or in some cases, private-sector developers), with predictable deliverables that neatly tick boxes of measurable performance indicators once a ‘solution’ has been implemented. This model may have had some success in the Global North, where financing is easier to come by, but most Global South cities do not have the resources or long-term operational and maintenance capabilities to sustain such project-based ‘investments’ over a long-term and at a scale large enough to generate substantive change. Taken from this standpoint, “green grabbing”⁵² can become a gateway to cumulative ‘solutions’ which, from the standpoint of residents in informal settlements, solve nothing.

Seeing NbS merely as ‘solutions’ reinforces a ‘project-based’ approach, since success (or failure) is relatively easily determinable against preset indicators (i.e., solutions). Of course, some kind of indicators are important, but concepts of socio-spatial justice, diversity of knowledges, recognition of value systems (which may differ from preconceived notions NbS frameworks have been constructed on), and meaningful interconnectedness of urban residents with natural realms are not easily quantifiable metrics to assess project success against. Even if we imagine they could be more easily measurable, relying on ‘project-based’ constructs of NbS delivery would be problematic in sub-Saharan African cities, for a number of reasons.

First, existing scholarship around the framing of NbS in sub-Saharan African cities emphasizes the role multilateral organization, donors, and NGOs play in their governance^{53–55}. Notably missing from this list are local public-sector actors, a sign that current approaches to NbS implementation as often practiced in the Global North may be poorly suited to these contexts. The often-siloed structure of public institutions can exacerbate implementation challenges of NbS, which—between servicing community needs and connecting NbS to larger resilience strategies—often requires interdisciplinarity, transcending scales and mandates⁵⁶. Communities don’t work in silos, even if governmental entities often do.

Second, even in the Global North, the degree of public financing needed to implement NbS at a scale necessary to meet climate change mitigation targets is beyond reach⁵⁷, and that is before one considers the availability of the land, itself a major impediment¹⁸. This is not to say that public financing is not important, only that it is insufficient. If the shortcomings of market-based mechanisms and project-based implementation in the Global North are clearly apparent, consider how this translates to much of the Global South, where monetary resources and institutional capacity are generally less plentiful. Socio-economic conditions, funding constraints, and limited data frequently hinder Global South cities’ capacity to extend basic services to informal settlements⁵⁸. Movement from public institution-led to less institutional governance models (rather than the other way around) is not always apparent in the Global South⁵⁹, and while standardized approaches from the Global North may complement conceptualization in the Global South, they should not be substitutes for locally-specific ones⁶⁰.

Third, the timelines associated with larger projects, often glacially moving through public tendering systems, are a difficult sell to residents in informal settlements already experiencing disasters while awaiting upgrading projects which may never arrive. Often, the omission of informal settlements from city-wide development plans and projects seriously limits the upscaling of NbS initiatives^{5,58,61}.

Complicating this further is the frequent overlooking or undervaluing of existing, self-initiated socio-spatial and socio-ecological initiatives self-managed by informal settlement residents themselves, supporting a capacity to adapt to changing circumstances in more nimble ways^{62–64}. In the face of reluctance or incapacity of public authorities, deeply engaging with these initiatives offers a means of exploring opportunities rather than initiating projects with fixed ideas of the outcomes⁶⁵, giving flexibility to the deployment of NbS resources in ways which achieve real benefit for residents, and enhanced management thereof^{66,67}. In essence, these practices reinforce a critique of ‘project-based’ approaches.

Clearly, more carefully considered paradigms of how NbS can achieve impact in sub-Saharan Africa are important to consider. A main driver of NbS is perhaps more likely to be organizations able to formulate new and alternative governance approaches that recognize trans-disciplinarity and plurality³⁷, rather than relying on institutional actors. The ‘project-based’ approach needs to be reconfigured, transforming into a more ‘network-based’ approach.

‘Networks,’ as used here, can be both physical (small interventions collectively contributing to a constellation whole) and relational (the interaction of knowledge held outside public institutions as socio-ecological infrastructure). A ‘network-based’ approach is one which keeps aims and goals realistic (often modestly so) and gives credence to local knowledge in creating deeply pragmatic solutions. Pluralistic valuations, in which values

and worldviews across a multitude of stakeholders are sought and used to assess potential trade-offs⁶⁸, make space for a broader set of stakeholder values to be considered, centering NbS on local needs and priorities. NbS as tactical urbanist or acupuncture interventions may be more likely to gradually bring wider structural changes³⁷, even if they do so slowly, aggregating interventions across multiple sites over an extended period of time.

A case study: the urban fabric initiative

Test cases of such ‘network-based’ approaches are out there. One study from Accra, Ghana, found self-initiated collective actions across multiple scales were able to implement infrastructural improvements more effectively (and adaptively to future changes) than formalized municipal efforts which had been proposed and rejected⁶². Another Ghanaian study—this one from Kumasi—found residents’ understanding of green infrastructure and desire to implement it to be fairly high, but a lack of faith in maintenance capacities and apathetic attitudes as hindrances⁶⁴; in other words, perceived reliance on external management structures rather than participatory problem-solving creates a significant impediment to implementation. A South African study⁶³ found residents’ self-implementation of NbS strategies (unknowingly and without technical expertise) in the riparian zone of river which traverses an informal settlement, created from the need for public green spaces and food production areas. A series of public space projects in the Kibera slum of Nairobi, Kenya by Kuonkuey Design Initiative (KDI) found that co-design and co-development of green infrastructure (primarily for increasingly resilient drainage networks) increased both the knowledge and perceived valuation of green infrastructure, improving long-term management and bringing otherwise skeptical municipal management to the table⁶⁹.

Among these test cases is the Urban Fabric Initiative (UFI), a series of experimental urban initiatives funded by Agence Française de Développement (AFD), primarily targeted at informal settlements in Africa, which “develop public spaces or local community facilities in a collaborative manner, and which support the animation of these sites through local dynamics”⁷⁰. Through the UFI, upgrading initiatives have been completed in 4 African cities (3 sub-Saharan) and in progress in 4 others, including Nairobi (where KDI, with other partners, is further testing the approaches described in the previous section), and in Kigali, Rwanda, where the author (with his practice and partners) is directly involved and can apply direct observation to this research.

Although funded by an international development agency, the formulation of the UFI – particularly in Nairobi and Kigali—has adopted a ‘network-based’ approach (see Fig. 1 for an overview of the network of upgrades), at least to the extent that procurement regulations within AFD and partnering governmental authorities allow. Predominantly structured around co-design and co-production of facilities, emphasis is placed on deep engagement, bringing public authorities ‘along for the ride’ in a capacity-building effort. In Kigali, although facilities are only now entering an implementation phase, the co-design process undertaken thus far has produced some important insights.

First, it revealed the extent to which organizing committees and governance structures within informal settlements already exist, and must be understood and engaged in order to facilitate progress. These structures have been aided by Rwanda’s unique governmental structure (highly centralized for budgetary purposes, but with what can best be described as ‘problem solving’ leadership posts and committees formalized at hyper-localized levels representing only a few hundred people), so cannot be said to have evolved organically. Community Upgrading Committees (CUCs) are also required by the national upgrading program and had therefore been set up prior to the launch of the UFI. Nevertheless, this setup underlines the importance of recognized representation, bought into by communities, in the design and decision-making process around urban development. The process thus far has revealed the extent to which organizing committees and governance structures within informal settlements already exist, and must be understood and engaged in order to facilitate progress. Each time a decision-making process or operation and management strategies were

proposed, the upgrading committees indicated a system was already in place for such forms of management.

It has also demonstrated that NbS can be integrated with a wide variety of micro-scaled projects, consistent with the ‘network-based’ approach. Facilities targeted for the Kigali UFI were not all initially framed as having NbS components; the emphasis was on social facilities. However, the stakeholder engagement revealed needs not identified in an earlier feasibility study which link directly to NbS as green infrastructure. Among the first facilities upgraded were water collection points which, absent NbS approaches, could have been left merely as managed stations for residents to fetch water. But the pairing of a technical site analysis unearthing considerable needs for erosion control measures on the small urban sites with a community needs assessment indicating a desire for greater access to shaded public green spaces allowed for the creation of an NbS framework as pocket interventions, connected to road and pathway improvements also offering opportunities for small-scale greenbelts across a multitude of sites, synchronized to a larger strategy (see Fig. 2 for examples). As the NbS framework developed, a ‘toolkit’ of interventions easily understandable by residents and implementable without substantial costs began to take shape: rainwater harvesting, bioswales, rain gardens & infiltration areas, terraced seating & gathering spaces, and pathways as biodiversity corridors.

Similarly, plans for a nursery school and community library initially slated for a site consisting of an open green space on public land was reallocated to another site – at the community’s behest—in order to preserve the limited green space available and maintain it for fully public use. The alternative site chosen was seen by community members as under-leveraged, as it did not function as part of a coherent system of spaces for public benefit, yet had potential to be transformed into another pocket of greenery offering ecosystem services. Thus, the work has morphed the program of social facilities into one of ecosystem services and NbS, even on sites and facilities which were not specifically earmarked for their inclusion.

These snippets of the process demonstrate the potential value gained through the participation process, and at least suggest that a ‘network-based’ approach can be keenly understood by informal settlement residents and unveiled through a deep engagement process.

Lessons from Sub-Saharan Africa Solidifying an approach

Arguably, urban NbS are more important for many sub-Saharan African cities than anywhere else⁴⁵—and particularly so for informal settlements. The limited existence of hard infrastructure and ontologically greater integration with natural systems found in most sub-Saharan African cities brings about the possibility for new approaches utilizing NbS to work towards less path-dependent approaches^{22,71} and become less encumbered by the limitations of scale.

Failure to align the provision of infrastructure and urban design to informal settlements residents’ existing resources, interests, and goals stifles the ability to improve residents’ livelihoods. The dominant way of organizing participation during planning processes—often a surface-level series of meetings in which residents are asked to react and approve rather than actively participate—misses the social process of appropriation which happens only after infrastructure has been delivered⁷², and which is complementary to the strictly ecological or infrastructural aims of NbS globally. To realize transformative change through NbS in sub-Saharan Africa, nuances and increased design sensitivities must consider how positive relational values of urban nature may be promoted⁵³. In the case of the UFI, existing community management structures, including a Community Upgrading Committee (CUC) and, as an added substructure to it, a Construction Committee (CC) were empowered to liaise on important design decisions and co-manage the implementation process independent of public authorities. Through these mechanisms, discussions of technical needs—including the inclusion of NbS—could be disseminated to wider audiences of residents already active in the management and care of small-scale infrastructure within their settlements.

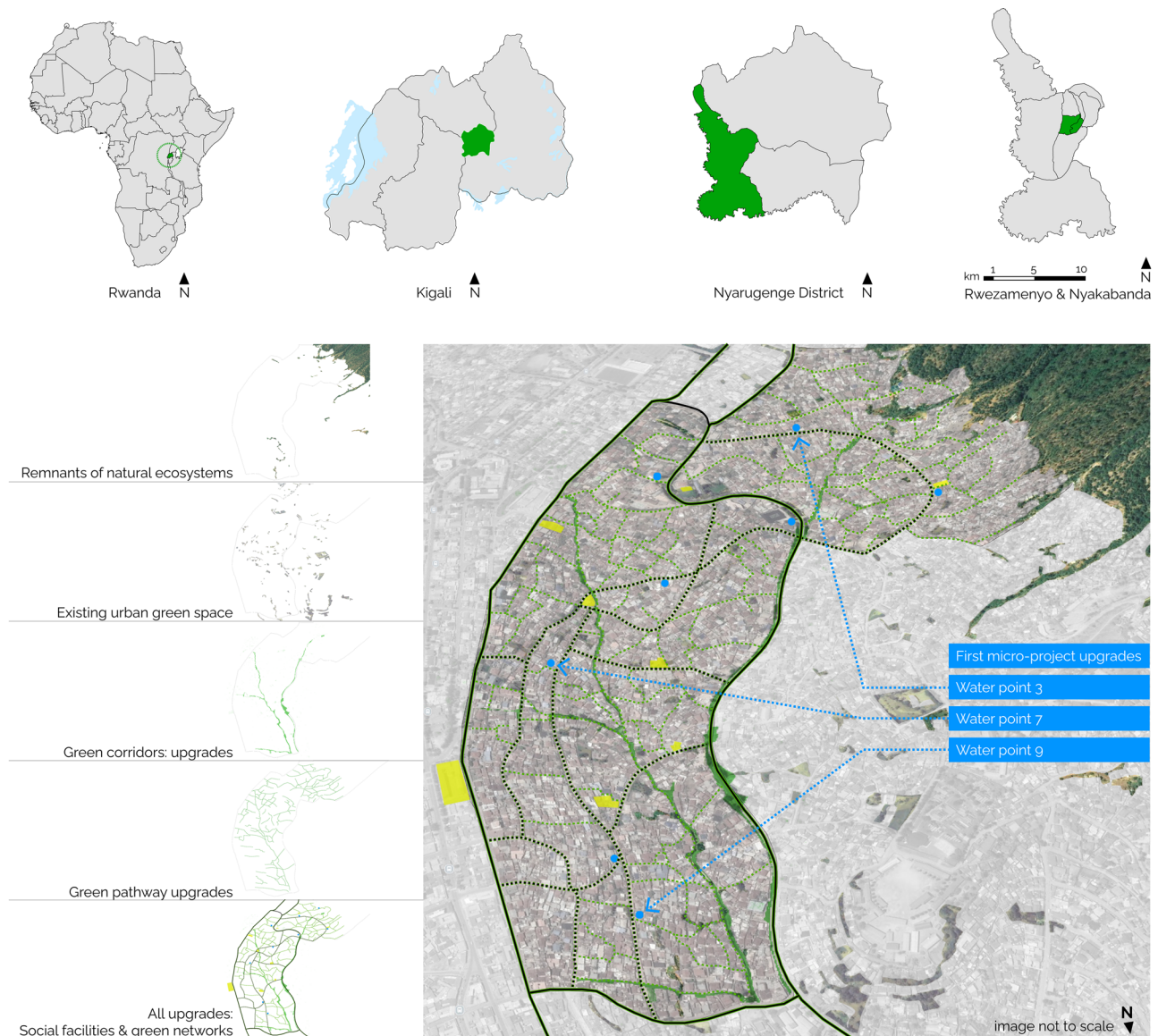


Fig. 1 | Projects develop incrementally along a strategic urban resilience plan. The diagrams at left indicate the various types of upgrading projects, some of which may occur over decades, while some small facilities are incrementally developed on

shorter time frames as part of the network-based approach. (Drawing by the author). Remnants of existing ecosystems overlaid with planned upgrades in Rwezamenyo and Nyakabanda, Kigali, Rwanda.

Whereas formal urban infrastructure and urban design interventions typically require considerable implementation budgets—potentially encouraging larger and larger projects which can capitalize on economies of scale—networked NbS interventions are better suited to be taken up organically, leveraging the uptake of newly-gained knowledge of some NbS design goals, features, and maintenance strategies as co-developed by the UFI technical team and the CUCs. By introducing a ‘toolkit’ of methods, small, incremental interventions can be developed over time, offering the potential for a feedback loop to develop as new facilities are appropriated and used, itself contributing to the collective maintenance capacity of new facilities over time. Many of the techniques deployable through NbS designs either require little technical knowledge or are dependent on skills that are transferable to groups and individuals which already contribute to governance systems in informal settlements, though not in any official capacity. The inclusion of capacity-building and passive knowledge transfer from designers and implementers to on-the-ground stakeholders can bolster a collective understanding of hazards and sensitivities being addressed⁷³, and even in the absence of supervising authorities, has some potential to create a snowballing of positive change. Even minute interventions may serve as

catalysts for wider adoption of similar techniques⁷⁴, thus insulating initiatives from reliance on institutions which may lack capacity. For the UFI water collection points, pre-existing management committees for self-initiated works are being upskilled with basic knowledge of urban resilience strategies designed into the projects, and a detailed maintenance regime is formally adopted into a caretaker’s contract. How this structure interacts with the UFI nursery school and library project is an ongoing concern, which may yield differing results.

The ability to derive place-based solutions to localized challenges enables the integration of communities’ lived experience with scientific expertise⁷⁵. The decentralization of the process – in essence, the opposite of a ‘project-based’ approach—allows for necessary flexibility to shape projects to collective needs under an umbrella strategy, and networked approaches create potential for a more responsive upgrading process which may incentivize residents’ inclination to at least inform, if not include, local governmental entities of upgrading activities suggests a means by which similar techniques can be more formally adopted⁶⁹.

This strengthening of local adaptive capacity is (arguably) among the more important outcomes of NbS implementation, and has a demonstrated



Fig. 2 | Three water collection points redesigned using NbS principles form part of the upgrading strategy. Examples of the first microproject upgrades (drawings not to scale).

track record⁷⁴ which is difficult to imagine happening in large-scale, project-based work. This kind of “process learning” points towards increasingly effective experiments and better insights⁷¹, guarding against the greater risks of large-scale interventions failing at larger scales. A ‘network-based’ approach is not inherently insulated against similar failures, but unsuccessful experiments become lessons learned, feeding newly discovered wisdom into the approach to the next intervention in the network. The co-design processes of the UFI facilities have already generated changes to how facilities such as water collection points are approached: a focus on passive strategies (large sheltering roofs with rainwater harvesting systems to reduce surface runoff, designation of rain garden/ infiltration areas as part of the public spaces, dense and biodiverse plantings) has gained traction with the CUCs, while more socially pragmatic facilities (public ablutions, market stalls) were lowered in priority due to perceived long-term maintenance challenges. To the UFI technical team, this was a somewhat unexpected outcome: residents willingly de-prioritized some responses to immediate needs in order to preserve capacity to implement and maintain pieces of a larger urban resilience agenda.

Du Toit⁷⁶ identified seven overarching barriers to the delivery of green infrastructure in sub-Saharan Africa: socio-cultural values, traditions and perceptions; lack of capacity; governance, planning and social inequity; lack of data; ecosystem disservices; spatial trade-offs; and climate change vulnerability. A networked approach has the potential to address – in full or in part—at least six of these seven. The ongoing co-design processes undertaken in the Kigali UFI, with small groups of stakeholders (often represented by the CUCs) but highly participatory, help ensure residents’ values are understood and incorporated, helping to break down the socio-cultural,

traditional and perceptual barriers defined by Du Toit, and ensure that spatial trade-offs are understood. The same process is itself a form of data collection, partially filling the data gap (albeit not at a macro-scale), incrementally forming case studies to draw from, and identifying and negotiating spatial trade-offs, to the extent they are predictable. A lack of institutional capacity is pre-emptive to the entire purpose of networked participatory processes; transferring capacity to additional parties and the inclusion of NbS knowledge transfers may bring considerations of climate change to the forefront, even if the actual impact towards it is of modest scale.

As opposed to ‘project-based’ interventions, a ‘network-based’ approach allows actions to be taken with relatively small budgets, and can be expanded as budgets become available, thereby alleviating some financial pressure on already cash-strapped cities of the Global South, and realigning approaches to NbS with on-the-ground realities. Such an approach, applied in Kibera, Nairobi^{48,69}, and in the UFI projects of Nairobi and Kigali⁷⁰, parallels other successful efforts elsewhere in sub-Saharan Africa which encourage small-scale experiments as a means to incrementally develop into larger systems^{77–79}, networking over time as larger-scale resources and planning efforts become available⁶⁹. Ideally, these efforts are guided by public authorities under larger resilience strategies and policies but are implemented using participatory means that remain cognizant of immediate local issues, challenges, and pluralistic value systems⁶⁸.

Conclusions

Scholarship and case studies of NbS in the Global South in general, and sub-Saharan Africa specifically, are relatively scarce, and additional case studies may add to the somewhat nascent knowledge base as these methods

proliferate. What can be gleaned from those already in practice, though, is that inclusivity of pre-existing operational structures in informal settlements is critical to NbS outcomes.

Reconstituting design and development towards more inclusive forms relies on contextually-appropriate interventions best attainable through inclusive processes without pre-set agendas. In most of Sub-Saharan Africa, this is likely to mean a focus on smaller-scale means, building constellations of work that collectively operate towards broader goals. Reliance on larger-scale, institutionally-driven projects is potentially ill-suited to the needs and challenges faced on the ground in informal settlements of sub-Saharan Africa. As opposed to a 'project-based' approach more common in the Global North, the cities of sub-Saharan Africa are likelier to benefit from a 'network-based' approach to NbS implementation through small-scale interventions which can become incremental building blocks towards larger resilience strategies.

Pushing this agenda requires a willingness to recognize a balance of decision-making power between experts and residents, something which is difficult to obtain when project objectives are defined in advance. An honest reckoning of the incapacity of the public sector to adequately deliver services to informal settlements, and a willingness to embrace alternative structures and solutions being practice on the ground, is necessary in order to infuse an NbS agenda into larger developmental strategies. At times, doing so may require unlearning development planning goals and urban design methods which have worked in better-resourced corners of the globe, and relearning, or reinventing, frameworks which are beginning to take shape in the Global South.

Data availability

No datasets were generated or analysed during the current study.

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Competing interests

The author declares no competing interests.

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