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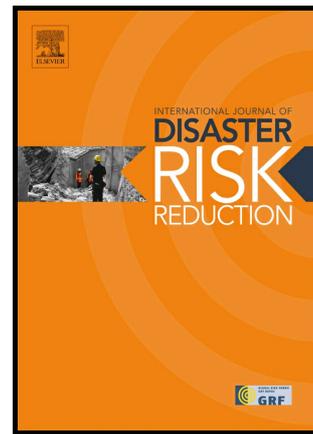
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Towards measurable resilience: A novel framework tool for the assessment of resilience levels in slums

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Abstract

This paper investigates the need for a generic technique to be applied in the assessment of resilience-related projects in slums - particularly for localised infrastructure at a community level - and proposes a novel framework tool for this purpose. The paper outlines the development of the framework tool, as well as its pilot testing on the Kenya Slum Upgrading Programme in Kibera, Nairobi.

1. **INTRODUCTION**

Slums are characterised by high densities of low-income populations, dilapidated housing stock, and limited or no access to clean water, sanitation and energy (Gulyani & Talukdar, 2008). UN-Habitat (2013) estimates that 836 million people now live in slum conditions, and that by 2030 over 3 billion people (40% of the world's population) will require adequate housing and access to basic infrastructure. With rapidly increasing global population and urbanisation, the United Nations Department of Economic and Social Affairs predicts that 66% of the world's population will be living in urban areas by 2050 (UN Department of Economic and Social Affairs, 2014). Coupled with this, disasters triggered by hydro-meteorological extremes are becoming more frequent and increasingly severe, costing $143 billion in 2014 (Urwin, 2014). Between 1980 and 2009 there were an estimated 540,000 deaths and 2.8 billion people affected by floods, with 50% of the flood-related deaths

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occurring in Asia (Doocy, et al., 2013). There is a growing body of evidence that urban populations in low and middle income countries are becoming increasingly susceptible to disasters (Dodman, Hardoy and Satterthwaite 2008). There has been a considerable interest, both in academic literature and policy formulation, in building the resilience capacity of urban populations, in particular of vulnerable communities in slums. Upgrading projects in slum settings present a set of unique challenges to planners and engineers as they are often characterised by resource constraints, high density housing, lack of land tenure, contested social power structures and marginalised localities.

2.   RESILIENCE

Resilience concepts and approaches have been adopted and applied by several academic and professional disciplines including engineering, psychology, ecology, organisational and management studies, and risk and disaster management (Alexander, 2013). The concept was first applied to the study of ecological systems by Holling in the early 1970s (Holling, 1973; Johnson & Blackburn, 2014), and has since been adopted and used liberally by various professions to frame a response to poorly planned and managed urbanisation. Béné defines resilience as:

 "any capacity and skills, and action, strategy, investment and anticipation, which helps individual[s], households and communities to anticipate, absorb, accommodate, or recover from the impacts of a particular adverse event (shock, stress, or (un)expected changes)." (Béné 2013)

Thinking and writing on disaster risk management has increasingly embraced resilience terminology and thinking, although there has been little consistency in understanding and usage. As a result, resilience is seen in many different ways. Traditional ideas of resistance to shocks and the ability to maintain or bounce back to the status quo, derived principally from engineering, are giving way to more progressive 'building back better' thinking about adaptive capacities and transformative processes (Handmer and Dovers, 1996; Manyena, et al., 2011; Pelling and Manuel-Navarrate, 2011; Kates, et al., 2012; Béné, et al., 2012). In parallel, there has also been a lively debate about appropriate conceptual frameworks for disaster resilience and how to apply resilience approaches operationally in disaster

planning, response and recovery (de Bruijne, et al., 2010; Cannon and Müller-Mahn, 2010; Manyena, 2006).

It has been argued that resilience is 'a poorly defined concept not yet operational for policy and management' (Klein, et al. 2003, p. 41). This seems to be an exaggeration, but field agencies and their staff have found it challenging to develop practical operational approaches out of the diversity, complexity and subtlety of resilience thinking. This paper discusses an initiative to address this operationalisation challenge in the specific context of urban slum settlements.

The concept of resilience is useful in seeking to understand communities and the risks to which they are exposed in a holistic manner, i.e. revealing how their economic, social and environmental stresses are interconnected. Furthermore, in a slum context the concept of resilience emphasises the need to understand informal settlement dynamics within the context of the wider urban fabric and in the extended timeframe of urban transition (Seeliger & Turok, 2014). Resilience theory seeks to minimise disruption to a system, accepting that uncertainty and change may lead the system to exist in multiple states of stability. Resilience is also closely associated with the notion of transformation (Pelling, 2011), implying that capacities of urban systems to endure or recover from the impacts (both direct and indirect) of climate change can be developed whilst simultaneously contributing to the much-needed transformation to a low carbon (local and global) economy where everyone's needs are met. Resilience-centred approaches to development have been criticised for prioritising technical solutions over a socio-centric approach (Bahadur & Tanner 2014). According to Smith & Stirling (2010) "... the focus on building resilience to shocks and ignoring long-term stress may lead to robustness which inhibits adaptability and transformability."

The resilience paradigm has been adopted by many major international development organisations since the Hyogo Framework for Action (HFA) in 2005. In practice, however, there have been relatively few attempts to incorporate resilience research concepts into actual urban development strategies (Engle, et al., 2014). Prominent among these was the Rockefeller Foundation's Building Climate Change Resilience Initiative ($70 million; launched in 2007) which was designed to enhance vulnerable communities' resilience to the effects of

climate change. This was followed closely (in 2009) by the foundation's Asian Cities Climate Change Resilience Network (ACCCRN) initiative to strengthen the capacity of over 50 cities in Bangladesh, India, Indonesia, the Philippines, Thailand and Vietnam to survive, adapt and transform in the fact of climate-related shocks and stresses. The ACCCRN has developed comprehensive resilience strategies on a city-wide level and examined similarities in terms of key challenges across cities. These include water infrastructure and drainage, robustness of energy infrastructure, improved transport systems, and basic sanitation infrastructure affecting public health (ACCCRN, 2015). Based on the ACCCRN initiative, a broad framework for urban climate resilience has been developed (Tyler and Moench, 2012). Other related work supported by the Rockefeller Foundation is focusing on development of a comprehensive city resilience index, derived from frameworks and indicators that can be used operationally by local administrations (Da Silva and Morera, 2014).

Action to increase resilience in slum communities has naturally been closely associated with improved infrastructure and infrastructural upgrading, as well as risk-based planning and relocation, but has thus far focused largely on the structural (or engineering) resilience of assets in response to unpredictable shocks. A number of case studies exist on slum infrastructural upgrading to improve livelihoods; however, because of the large variations in slum development and context globally, these are generally localised to specific communities. A question therefore arises about whether there is a significant dislocation between the frameworks adopted by national governments to build climate change resilience, which often involve top-down planning and community relocations, and the localised infrastructural projects to improve livelihoods that prioritise community participation and involvement to ensure successful implementation and long-term sustainability. Eriksen et al. (2011) elaborate on this point, suggesting that whilst adaptation can mitigate against the negative effects of climate change, little attention has been paid to the consequences of these policies and projects in terms of sustainable outcomes. Adger et al. (2011) argue that "There is growing evidence that current policy approaches to climate risk which stress short-term benefits and seek simple technological fixes to complex problems fail to significantly address multiple and interacting factors which affect system resilience and the needs of vulnerable populations".

Birkmann et al. (2010) highlight the mismatch between spatial scale, temporal scale, functional scale and societal norms and behaviour when considering adaptation and building of infrastructure after a disaster. For e.g. it appears that the climate change resilience frameworks imposed by the development community have left institutions in the "global south", some of which find up to 70% of their population living in slums (Johnson & Blackburn, 2014), with a dilemma of how best to implement a broad plan of action in terms of successful (and sustainable) infrastructural upgrade. Most of the city scale plans exclude localised community based approaches which are context specific. There is a need to therefore, develop a strategy for enhancing and building of infrastructure which is localised and inclusive.

3.   FRAMEWORKS FOR MEASURING RESILIENCE: CURRENT APPROACHES AND CHALLENGES

The quantitative measurement of resilience has been contested in recent literature, with some academics, NGOs and aid organisations claiming that it is too complex a concept to put a number to, and others claiming that its quantification is vital as a diagnostic tool for assessing interventions in communities and cities. Levine (2014) states that attempts to measure resilience have thus far been insufficient due to a lack of agreed understanding of the concept itself. He defines three key concerns that lie behind the demand for better resilience metrics: (1) the need to pay more attention to vulnerability in development policy and aid, (2) the need for development policy to think more about an uncertain future, and (3) the need to transform the way in which the collection, analysis and use of evidence for decision making (including quantified evidence) is carried out. Winderl (2014), reviewing a wide range of methods and tools, identifies a lack of consensus about how to measure resilience, showing the variety of ways in which the concept (and its different dimensions and components) can be viewed and interpreted.

Developing a generic technique to measure resilience faces several operational challenges, including the multi-scalar and multi-dimensional nature of resilience. Assessment techniques are often specifically designed to examine a household, community or city; however almost none are capable of scaling across these systems. Indicators that view

resilience through a lens of one scale (e.g. aggregate national level) will gloss over the factors that affect resilience at other scales (e.g. community level) and also overlook trade-offs across scales (Engle, et al., 2014). Béné (2013) states that resilience, by nature, is time, space, livelihood and stress (or shock) specific; however, a framework must be generic enough to be able to compare different communities in different contexts. Additionally, resilience is often measured in hindsight of a shock (e.g. a natural disaster), and so methods of measuring resilience in terms of cost or asset depletion have regularly been employed. This approach is limited in scope. There is a need for additional recognition of the negative impacts of extensive risk and long-term stresses on households and communities (Jones and Bahadur, 2013).

Levine (2014) identifies five approaches to measuring resilience currently in use: (1) quantification based on functionality, (2) quantification based on indicators and characteristics, (3) quantification based on food access, (4) quantification based on activities, and (5) quantification derived from theoretical resilience frameworks. Quantification based on indicators and characteristics is gaining the most traction within the aid community, which has prior experience with this technique (the Human Poverty Index, Human Development Index etc.). To date, frameworks to implement resilience projects developed by international aid organisations have made little or no attempt to quantify the impact of their interventions (Levine, 2014; Béné, 2013), and serve rather as a set of best practice guidelines. An extensive number of indicators have been suggested to measure and quantify resilience. Normandin et al. (2009) conducted a broad review of current literature on city resilience which identified 273 cited indicators. Through an analysis of 9 relevant case studies, their work found that just 31 of these indicators (11%) were present in two studies or more, highlighting the diverse range of theory from which resilience thought has emerged. Arup's study of measurement of urban resilience recognises that any framework to measure city resilience "would need to use a vast number of variables that draw on a wide range of interacting systems within a city. However, having a large number of variables makes it difficult to quickly understand the degree of resilience of a city." (Da Silva and Morera, 2014). Without more generic or standard frameworks for measuring the impact that development work has on resilience, projects have thus far been measured using context, project and often time-specific indicators (Béné, 2013). Alternatively, resilience can

be viewed as a combination of different forms of capital or asset: social economic/financial, natural, human, physical and political (Mayunga, 2007). These, which are derived from earlier sustainable livelihoods analysis approaches (Carney, et al., 1999) have been absorbed into a number of resilience frameworks.

Typically, infrastructure projects tend to be delivered with the emphasis on technical performance within the realms of project boundaries rather than recognising their long term contribution to the development of the communities they serve or are located in. The ASPIRE (A Sustainability Poverty and Infrastructure Routine for Evaluation) toolkit developed by Arup and Engineers Against Poverty (EAP) aims to integrate the agendas of poverty reduction and development for community-based infrastructure projects (Engineers Against Poverty and Arup, 2009). This toolkit has the flexibility of being applicable to both large and small-scale infrastructure projects, integrating institutional, economic, social and environmental considerations through a range of indicators. However, the toolkit does not consider the resilience of community-based infrastructure.

Much of the research conducted on resilience has been concentrated on either a city-wide scale (e.g. the resilience of vital systems to shocks and stresses), or on an individual or household level (e.g. the inherent resilience of humans to endure shocks and stresses). In the case of resilience research on slum-dwellers, the latter tends to be emphasised. Our proposed framework therefore specifically targets this perceived gap of a community-level assessment tool. Whilst, the enabling environment, disasters and environmental shocks does have a role to play in influencing community actions there is still value in exploring the characteristics of a resilient community. John Twigg (2009) highlights that a focus on resilience shoud be about putting greater emphasis on what communities can do for themselves rather than concentrating on their vulnerability to disasters or environmental shock.

4. TOWARDS A RESILIENCE ASSESSMENT TOOL

There is a clear necessity for an independent assessment technique that is generalised enough to holistically consider resilience across time frames and locational contexts. Béné (2013) identifies the following requirements of a framework for measuring resilience:

I.   **Multi-scale:** Resilience indicators should be able to capture change in resilience at different scales, and should not be limited to individuals, communities or even cities. The scope of this paper is to develop a community based resilience toolkit so the scale has set to community based localised projects.

II.   **Multi-dimensional:** Resilience is not simply about coping strategies that help households to survive a shock: it is also about adaptive or even transformative strategies. It is about ex-post but also ex-ante (anticipation) strategies. An appropriate resilience framework would be one that captures all these different dimensions.

III. **Objective and subjective:**   Resilience indicators should aim at monitoring both objective changes and subjective perceptions – including stress.

IV.   **Generic:** Although it is recognised that indicators are relevant only if they can capture and reflect the specificity of the situation they are applied to, many indicators are currently built on specific circumstances, contexts or agendas. An appropriate resilience indicator is one that can be scaled up and replicated.

V.   **Independently built:** To be analytically useful, a resilience indicator needs to be defined and measured independently from the factors and processes that affect resilience such as income, assets, level of participation or social coherence. This allows us to explore and test rigorously the actual effect of these factors and processes on resilience.

In addition, there is a need for a resilience measure which can be applied easily to localised community-based services. This implies that the measure should be relevant to the local context and can be applied easily by local organisations. The ASPIRE framework and toolkit has proven to be effective for use in sustainability assessments for community-based projects in Asia and has been used extensively by organisations such as Habitat for Humanity (Maynard, et al., 2014). The ASPIRE toolkit was specifically developed to integrate poverty and sustainability agenda for infrastructure projects with an opportunity to clearly define the scale, project boundary and temporal dimension. ASPIRE also meets the

requirements proposed by Béné (2013). It is therefore proposed to align and develop a new framework for resilience building on the process and methodology used for ASPIRE. It is envisaged that the new framework will be utilised by NGOs, development agencies and policy makers to assess the resilience-building effects of projects (particularly infrastructural in nature) in rural, urban and peri-urban slum communities.

We have drawn on the work of Arup International Development (2011) which, in collaboration with The International Federation of Red Cross and Red Crescent Societies, conducted extensive research into resilience assessment techniques, combining numerous respected bodies of work to create a comprehensive list of the characteristics of a safe and resilient community, both urban and rural. The list identifies 16 sub-categories with 49 indicators under four main categories: external resources, assets, capacities and qualities, encapsulating the multi-dimensional aspect of resilience (Table 1).

Table 1: Resilience characteristics (Adapted from Arup International Development, 2011 and modified by authors)

External resources	
Connections and information	**Indicator**
Transportation and infrastructure	Assess the provision of affordability, safety, connectivity, availability and necessity of transport provision.
Communication and information	Evaluate the extent of dialog between community and authorities and the transparency of decision-making.
Technical advice	Does the community have access to professional resilience and disaster institutional support?
Services	
Municipal services	Assess the availability of municipal services such waste collection, water provision, fire department, and police.
Medical care	Does the community have access to reliable medical facilities and what state are these facilities in?
Government and other funding	Is there easy access to local and foreign funds?

sources

Natural resources

Land	Assess the ownership, vulnerability and affordability of land.
Water	Assess the available water infrastructure, quality of supply and its reliability.
Ecosystems	Is the surrounding environment protected (including biodiversity, water and air)?

Assets

Physical assets	**Indicator**
Public facilities	What public facilities are provided to the people and in what state are these?
Housing	How robust are the housing communities and how susceptible are these to collapse?
Transport infrastructure	Assess the provision of transport infrastructure (i.e. road, rail and bus).
Stockpiles for emergencies	Are medicine, medical supplies, food and water available to protect the community?

Economic assets

Livelihood assets	Assess the distribution of wealth and livelihood assets in the community.
Employment and income	Assess the availability of local economic activity, its sustainability and employment opportunities.
Savings and contingency funds	Assess the status of personal savings and access to financial support.
Investment	Do members of the community have investment contingencies?
Insurance	Does the community have access to affordable insurance plans for their assets?
Business and industry	To what extent do local businesses thrive and how much access to business support does the community

have?

Environmental assets

Ownership of natural resources	What is the availability of natural assets and does the community have access to these?

Human assets

Local and traditional knowledge	Assess the value of local and traditional knowledge (i.e. information, values and mental models).
Skills	Assess the community's general skills necessary to help them deal with stresses.
Language competency	Do all members of the community speak the same language(s)?
Health	Is the community medically aware and do they have access to skilled medical (local) staff?
Education	What is the level of education and literacy in the community and how affordable is it?

Social assets

Community cohesion and cooperation	Evaluate the known community segregation, past violence occurrences and subsequent resolutions.
Religion	Evaluate the known religious segregation, past violence occurrences and subsequent resolutions
Community organisations with collaborative/partnership relations	Are community organisations, capable of managing shocks and stresses, locally present?

Capacities

Resourcefulness

Mobilise resources	Assess the community's ability to mobilise different resources when responding to shocks or stresses.
Visualise and act	Assess the community's ability to use past experience when acting on the threat of future shocks and stresses.
Identify problems and establish	Assess the community's ability to foresee and identify

priorities	severe problems affecting livelihoods.
Innovate	Evaluate range of jobs available, diversity of skills required and past innovation exposure.
Coordinate	Does the community have a task force that forms part of an emergency response plan?
Adaptive and flexible	
Adapt to long-term trends	Evaluate the community's ability to adapt over the long-term to changes that contribute to uncertainty.
Convert assets	Evaluate the ability to convert and diversify assets / liquidity to activities.
Accept uncertainty and respond to change	Does the community have organisations and access to resources to gyrate community response?
Learn	
Build on past experience and integrate them with current knowledge	To what extent does the community use previous experiences and knowledge of shocks and stresses?
Assess, manage and monitor risks	Does the community have the ability to actively assess, manage and monitor risks?
Build back better after disasters	Does the community have the capacity to adapt to changes following a shock or stress?
Qualities	
Strong/robust	
Withstand external pressure or demands	How did the community respond to past exposure to pressure or demand and what were the lessons learnt?
Strong	Describe the strength and durability of the infrastructure and any signs of disrepair and disuse.
Increased size	What is the community's ability to increase contingency and emergency funds?
Well located	
Geographically distributed	Are assets distributed in different areas of the community?

Located outside high risk areas	Is there a map identifying all the high-risk areas? And what is their proportion?
Diverse	
Able to meet its needs in a variety of ways	Assess the portfolio of activities and social support capabilities available to the community.
Redundant	
Spare capacity to accommodate pressure	Assess the ability of a system (natural or human) to respond to and recover from the effects of stress.
Equitable	
Equal and inclusive access and ownership	How evenly distributed are assets in the local community and does everyone have a stake in owning them?
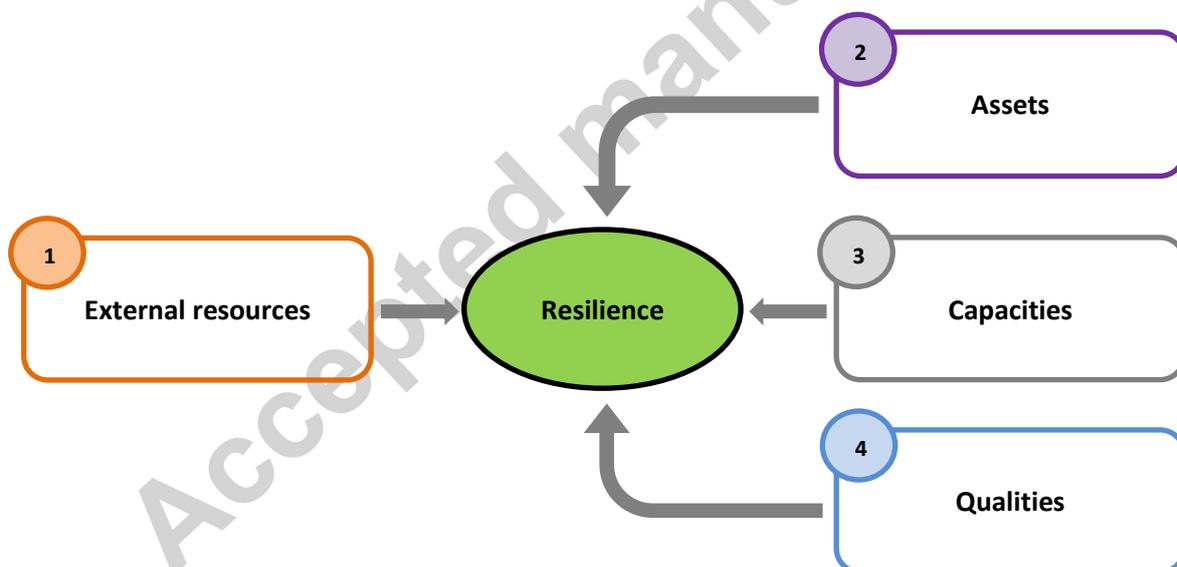
Figure 1: Architecture of the assessment model

Figure 1 summarises the interlinkages between the four key headings of Assets, Capacities, Qualities and External Resources for building resilience in local communities within the qualitative framework. For each heading there were qualifiers identified as sub-headings. Indicators were developed for the four headings based on qualifiers identified in Table 1. So

for example, for the key heading of 'external resources' one of the qualifiers would be 'connections and information' which was supported by three indicators.

The assessment process and indicators were developed to be qualitative in nature thereby eliminating the need for large amount of data collection and training. The indicators support qualitative assessment that can be carried out to varying degrees of accuracy depending on the nature and amount of data collected on a specific community. In order to ensure that the assessment is holistic and inclusive, all indicators are deemed to have equal weightage. This also eliminates likely user bias as various stakeholders would prioritise indicators depending on their perception of the project. The model was developed to support local practitioners in the field who would use the project evidence combined with stakeholder feedback to provide their assessment. An equal weightage ensures an independent and consistent assessment of all factors contributing to resilience.

For each indicator, a definition of the best case and worst case scenario is given, based on the research from which it was included in the list (Figure 2). Each of the 49 indicators is assigned a score on an ordinal scale ('very poor, poor, fair, good and very good'). The user is prompted to add a justification as a means of reference for each indicator score. A number from 1 to 5 is automatically assigned to each indicator score (e.g. very poor = 1 and very good = 5). The indicators are categorised as areas of strength (very good, good) if the score was between 3.51 to 5.00, areas of concern (fair) if the score was between 2.51 to 3.50 and then areas of weakness (poor, very poor) if the score was between 1.00 to 2.50. Each of the 16 qualifiers under the four key headings are then averaged, and used to identify areas of strength, concern and weakness.

EXTERNAL RESOURCES

Category	Indicator(s)		Rating	Justification
Connections and information				
	Very poor	**Very good**		
Transportation and infrastructure	No safe, affordable transport provision. Residents have to walk long distances to get to places of work	Adequate provision of public transportation and access e.g. Busses, trains etc		
Communication and information	No open dialog between the community and authorities. Community is not consulted regarding decisions made prior to projects.	Established social information and communication channels; vulnerable people not isolated. Community exchanges information with government and other actors. Community receives early warning about shocks.		
Technical advice	Community has no access to professional assistance for projects that they wish to undertake.	Community has access to technical advise and support from external agencies e.g. Infrastructural repairs or retrofitting.		
Services				
	Very poor	**Very good**		
Municipal services	Total lack of municipal services e.g. Waste collection, policing etc.	Functioning municipal services e.g. waste collection, policing etc.		
Medical care	No external provision of medical care and emergency response strategies. Total lack of hospitals and doctors servicing the community.	Access to external provision of medical care and emergency response. Sufficient number of hospitals and doctors servicing the community.		
Government funding	No provision of external funding for community projects and upliftment.	Government and other external sources provide adequate funding for the bettering of community livelihoods.		
Natural resources				
	Very poor	**Very good**		
Land	Community has no rights or deeds to land.	Security of land tenure given to the community by authorities.		
Water	No provision of clean, safe drinking water.	Adequate access to clean, safe drinking water provided by municipal infrastructure.		
Ecosystem	No external protection of environment including biodiversity, water and air.	External protection of ecosystem which provides clean water, air and a stable climate.		

**Figure 1: Example of framework structure**
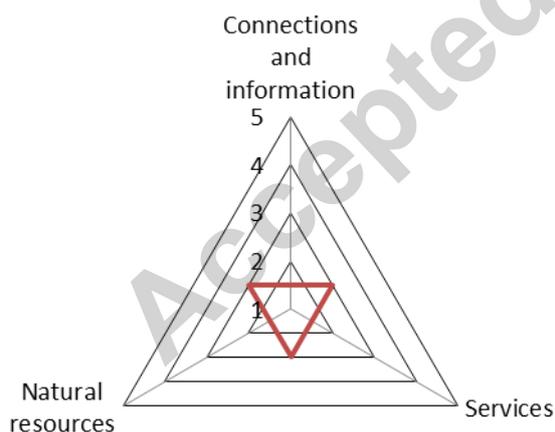
Figure 2: Radar graph of assets category

The output tab automatically identifies the strongest and weakest indicators for each category, as well as tabulating the categories based on their average score ranges. The

average scores are also colour coded green, orange or red based on their range for easy identification of performance. A radar graph (Figure 3) is generated for each of the four sectors to provide a graphical representation of the indicator scores. Averaging across indicators may lead to areas of severe weakness being masked by areas of strength under the same category, and therefore care should be taken to note and highlight individual indicators that are weak. In order to address this risk the option of a "best case scenario" and "worst case scenario" output has also been included where the high and low scoring indicator scores within each qualifier is displayed in the graph. Comparing these outputs against the averaged output provides rapid identification of outlier indicators that may be skewing a qualifier.

5. TESTING THE FRAMEWORK

The framework was tested in two stages. An early prototype of the framework was tested in a workshop at University College London with doctoral students engaged in urban sustainability and resilience research. Key feedback from the workshop included the need for greater clarity on boundary conditions, and a change of scale from best to worst (instead of very good and good which is difficult to define). The average scores appeared to mask the strengths and weaknesses within each section so the framework was modified to display the indicator scoring more clearly.

The resilience framework was then tested on a case study in Kenya. The Kenya Slum Upgrading Programme (KENSUP) was selected as a case study on the basis that it included localised community based infrastructure interventions with ongoing monitoring and evaluation carried out by UN-Habitat making data collection feasible.

KENSUP is an ongoing collaboration between UN-Habitat and the Kenyan government set up in 2004 for improving living conditions of slum dwellers in Kenya. In 2007, KENSUP targeted Soweto East: one of the 12 large peri-urban villages of Kibera on the outskirts of Nairobi. Soweto East, with a population of roughly 71 000 (UN-Habitat, 2014), is characterised by dense shack dwellings situated on flood plains, with poor transport access and inadequate water and sanitation services. The main scope of the intervention covered the development

of small-scale community based infrastructure (water, sanitation and waste management) supported by capacity building for local communities. The project also included improvement of governance structures in order to facilitate replication at scale.

The authors gathered information through literature review by targeting UN-Habitat and independent project assessments in addition to peer reviewed articles published in developmental journals. UN-Habitat (2014) developed strategy documents prior to implementation and also carried out a post project assessment to evaluate the performance of KENSUP. Those documents were used to carry out the resilience assessment of Soweto East and test the prototype framework.

To ensure verification of evidence collated through the literature review, semi-structured interviews were conducted with stakeholders. Relevant stakeholders were identified through snowballing techniques and categorised into three key stakeholder groups: UN-Habitat, local residents and slum upgrading experts all of who had extensive knowledge of the KENSUP project. The respondents were then interviewed via Skype and phone. The information collected from secondary as well as primary research was then fed into the prototype framework to assess resilience of the KENSUP initiative. The resilience of Soweto East community was assessed both before and after project implementation to see how the KENSUP intervention may have influenced resilience at community scale. The authors scored the indicators across the 16 sub-categories of the prototype framework. For each score the authors provided evidence and justification to ensure transparency. Refer to Appendix A for justification and detailed scores. Table 2 presents the average scores of the 16 sub-categories, along with the best and worst indicator scores in each category. 13 of the categories were placed within the "area of weakness" bracket (highlighted in red), two in the "area of concern" bracket (highlighted in yellow), and just one in the "area of strength" bracket (highlighted in green). The assessment clearly highlights the sources of greatest deprivation, largely stemming from a lack of government assistance (municipal services, medical care etc.) and few economic opportunities, leaving the community trapped in a cycle of poverty and extremely vulnerable to shocks and stresses.

Table 2: Assessment of Soweto East prior to KENSUP

Indicator	Average	Best indicator	Worst indicator
External resources			
Connections and information	**2.67**	Good	Poor
Services	**1.33**	Poor	Very poor
Natural resources	**1.00**	Very poor	Very poor
Assets			
Physical assets	**1.50**	Poor	Very poor
Economic assets	**1.33**	Fair	Very poor
Environmental assets	**1.00**	Very poor	Very poor
Human assets	**1.80**	Poor	Very poor
Social assets	**3.67**	Very good	Poor
Capacities			
Resourcefulness	**2.20**	Fair	Very poor
Adaptive and flexible	**2.67**	Good	Poor
Learn	**1.67**	Poor	Very poor
Qualities			
Strong/robust	**2.33**	Fair	Poor
Well located	**2.00**	Poor	Poor
Diverse	**1.00**	Very poor	Very poor
Redundant	**1.00**	Very poor	Very poor
Equitable	**1.00**	Very poor	Very poor

Table 3 and Figure 4 present the summary of the assessment after the project was completed. The KENSUP project was for the most part managed to address the provision of infrastructure and was able to make a significant impact in the areas that it targeted. Substantial gains were noted in building an asset base for the local community.

Table 3: Assessment of Soweto East after KENSUP project completion

Indicator	Average	Best indicator	Worst indicator

External resources

Connections and information	**3.33**	Good	Fair
Services	**3.00**	Good	Poor
Natural resources	**2.33**	Fair	Very poor

Assets

Physical assets	**2.75**	Good	Poor
Economic assets	**2.67**	Good	Very poor
Environmental assets	**3.00**	Fair	Fair
Human assets	**3.40**	Good	Poor
Social assets	**4.00**	Very good	Fair

Capacities

Resourcefulness	**3.00**	Good	Poor
Adaptive and flexible	**3.00**	Good	Poor
Learn	**2.67**	Fair	Poor

Qualities

Strong/robust	**3.00**	Fair	Fair
Well located	**2.00**	Poor	Poor
Diverse	**3.00**	Fair	Fair
Redundant	**1.00**	Very poor	Very poor
Equitable	**1.00**	Very poor	Very poor
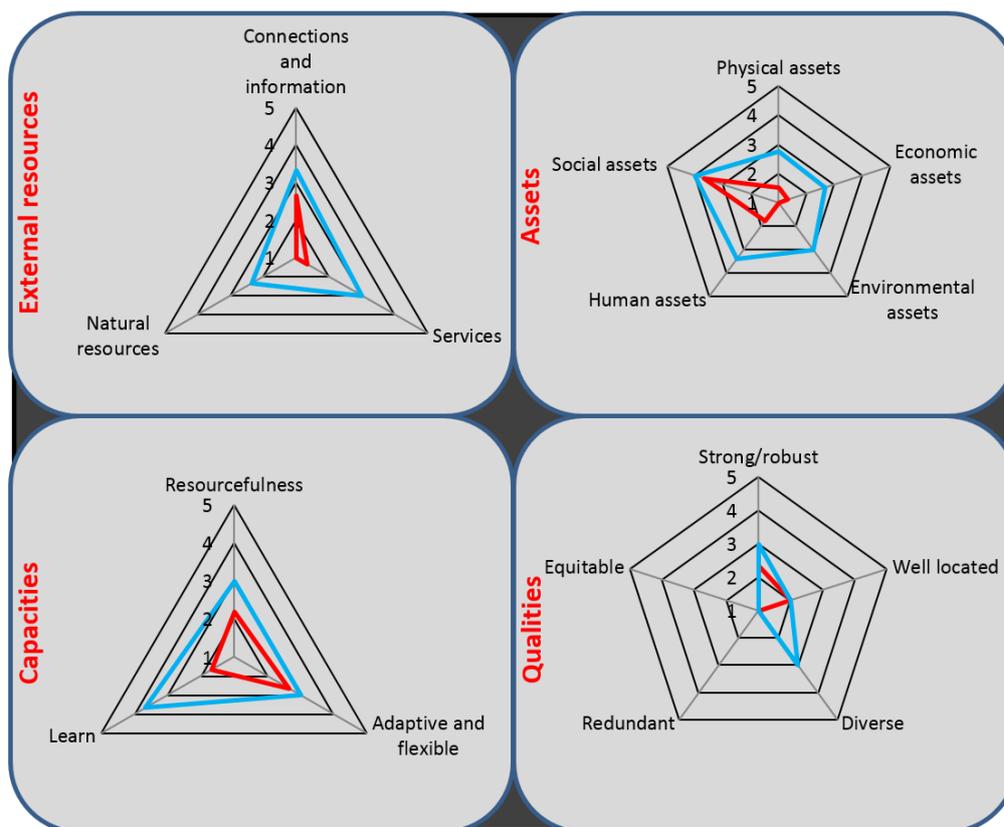
Figure 4: Radar graph of all categories before (red) and after (blue) the KENSUP intervention

Nine of the sub-categories that were previously rated as an "area of weakness" were increased to the "area of concern" bracket, leaving four of the sub-categories as an "area of weakness" (Appendix A). The greatest improvements were recorded in the equitable access to natural resources through improved communication between the community and the authorities, and the increased livelihood opportunities emerging from the transfer of skills and training, as well as increased economic activity. Basic municipal services improved through the installation of improved water, sanitation and waste collection. Social assets was the only sub-category that scored as an "area of strength," improving due to increased community cohesion and the furthering of relationships with the NGOs and charities operating within Soweto East.

The tool also indicates the multi-faceted nature of slum upgrading and resulting direct and indirect impacts. For example, the way in which the health-related indicators increased after

the project intervention possibly through improved sanitation and water, and new business was attracted to Soweto East by improving the internal transport networks. The lack of secure land tenure is still a major issue for the community of Soweto East as they remain vulnerable to forced relocation and eviction. Security of land tenure would almost certainly encourage the residents to invest more of their limited resources into improving their housing stock and surrounding assets.

6. CONCLUSIONS

The prototype resilience framework was tested on a slum upgrading project in Kenya involving the provision of localised infrastructure services. The evaluation demonstrates an improvement in asset base, capacities and external resources for the community post intervention. The lack of land tenure was identified to be a key weakness and factor which impacted resilience of the local residents. The results from the prototype framework align with perception of stakeholders engaged in the KENSUP project. One of the challenges noted in the prototype was identification of the project/case study boundary and boundary conditions. For example, some of the project scope and impact was linked to activities outside Soweto East which were not covered by the assessment. Another challenge noted was lack of clarity on how the indicators were defined and derived. It is proposed to develop a manual which clearly indicates definition of boundaries and presents the rationale behind the development of all indicators. This would enable stakeholders in the field to apply the framework effectively.

The prototype framework needs to be tested at scale with multiple users to ensure due diligence and consistency. This is critical as the framework is qualitative and hence it is reliant on user perception and judgement. It would be interesting to assess results obtained from multiple stakeholders assessing the same case study and noting differences in scoring. Additional future work would include testing on a wider sample of case studies and reviewing the components of the framework to ensure application in a global context. In order to enable a larger scale testing it is proposed to approach engineering consultancies

who are actively engaged on infrastructure projects to see if there is scope to apply the framework to some of their projects.

The added value of the prototype tool discussed in this article is its application to informal settlements and the ease of use with limited data. There is a dearth of toolkits which can assess resilience of community based projects taking into consideration the local context. The prototype framework discussed in this article would enable community based agencies and local stakeholders to assess resilience of projects through a rapid appraisal process. The toolkit is suitable for practitioners working in the field who have limited access to data and have limited resources to carry out extensive household interviews. The assessment relies on user perception and judgement as a substitute for high quality evidence. This is a limitation of the toolkit which can be addressed through quality assurance processes where an assessment carried out in the field is then reviewed by an independent reviewer. The assessment can also be presented to the local community in a workshop to assess if the outputs align with their perception.

Resilience has recently become an area of great interest for development agencies and policy makers alike, and has significant potential for a systematic approach to reducing the vulnerabilities of marginalised populations. There is strong evidence to suggest that there is a gap in research surrounding how best to measure and quantify the impacts of upgrading projects on resilience capacity, largely due to conflicting understandings of this complex paradigm. The proposed tool attempts to measure resilience across contexts and time periods, applying a set of generic indicators to assess the level of resilience in a community. The full potential of this tool would be realised by utilising it for project planning as a way to promote thinking on the interconnected and multi-dimensional nature of resilience, and move project thinking away from a techno-centric approach to one of holistic social, economic and environmental inclusivity.

APPENDIX A

Assessment prior to KENSUP intervention:

EXTERNAL RESOURCES

Category	Indicator(s)		Rating	Justification
	Very poor	**Very good**		
Transportation and infrastructure	No safe, affordable transport provision. Residents have to walk long distances to get to places of work	Adequate provision of public transportation and access e.g. Busses, trains etc.	Good	Busses are available but there is no transport infrastructure within Kibera. Adequate access to trains.
Communication and information	No open dialog between the community and authorities. Community is not consulted regarding decisions made prior to projects.	Established social information and communication channels; vulnerable people not isolated. Community exchanges information with government and other actors. Community receives early warning about shocks.	Poor	No liaison between community and government. Government is planning a relocation scheme but this has been widely opposed due to higher rents. Power struggle between ethnic groups within Kibera.
Technical advice	Community has no access	Community has access to	Poor	Mostly provided by NGOs and

Connections and information

	to professional assistance for projects that they wish to undertake.	technical advice and support from external agencies e.g. Infrastructural repairs or retrofitting.		charities.

Services

	Very poor	**Very good**		
Municipal services	Total lack of municipal services e.g. Waste collection, policing etc.	Functioning municipal services e.g. waste collection, policing etc.	Very poor	Almost no toilet facilities. Pit latrines are dug by the residents and service up to 50 households each.
Medical care	No external provision of medical care and emergency response strategies. Total lack of hospitals and doctors servicing the community.	Access to external provision of medical care and emergency response. Sufficient number of hospitals and doctors servicing the community.	Very poor	Government provides no medical care within Kibera. Government do provide free ARVs for HIV positive members.
Government funding	No provision of external funding for community	Government and other external sources provide adequate funding	Poor	Little motivation by government to invest in improvement.

	projects and upliftment.	for the bettering of community livelihoods.	Landlords connected to politicians and don't want to lose their income.
Natural resources			
	Very poor	**Very good**	
Land	Community has no rights or deeds to land.	Security of land tenure given to the community by authorities.	Very poor	Land owned by government or landlords who view it as a source of income.
Water	No provision of clean, safe drinking water.	Adequate access to clean, safe drinking water provided by municipal infrastructure.	Very poor	Until recently water was collected from Nairobi dam is polluted and causes typhoid and cholera. There are now 2 mains connections provided by private dealers.
Ecosystem	No external protection of environment including biodiversity,	External protection of ecosystem which provides clean water, air and a	Very poor	Sewage is allowed to be dumped directly into water courses.

water and air.	stable climate.		

ASSETS

Category	Indicator(s)		Rating	Justification
Physical assets				
	Very poor	**Very good**		
Public facilities	No provision of public facilities or public facilities have fallen into disrepair.	Adequate public facilities and infrastructure that have been maintained and protected through retrofitting, upgrading and rebuilding.	Very poor	Only 20% electrified. Building materials are often stolen.
Housing	Housing is structurally inadequate and unsafe e.g. Constructed from corrugated iron and other scrap materials.	Housing is structurally sound (not mobile).	Very poor	Dwellings are largely mud walled and floors with corrugated tin roof. Constructed on dumped refuse which leads to collapse.
Transport infrastructure	Lack of road and rail servicing the	Adequate transport infrastructure	Poor	No internal roads or rail. Residents have

	community.	e.g. road, rail and bus.		to walk to bus and train stations.
Stockpiles for emergencies	No spare capacity to provide emergency relief in a time of crisis.	Access to stockpiles of emergency food and medical supplies, as well as access to emergency shelter.	Poor	Very little provided by government. NGOs and charities assist with disaster relief to some extent.

Economic assets

	Very poor	Very good		
Livelihood assets	Inequality in distribution of wealth and livelihood assets in community.	Equitable distribution of wealth and livelihood assets in community (DIFD Livelihoods Framework).	Very poor	Residents are victimised by private suppliers of resources.
Employment and income	Lack of economic activity and employment opportunities within or surrounding the community.	Good levels of local economic activity, sustainability in economic activity and employment. People can take alternative	Very poor	Over 50% unemployment. Majority of the community live on less than $1/day.

employment.

Savings and contingency	Community members have little or no savings and are excluded from financial support.	Households or community has savings or can access grants and loans. Access to micro-finance schemes.	Very poor	Majority of community do not earn enough to save anything. No access to external finance.
Investment	No investment contingency that can be used in times of need.	Households or community have investments that they can rely upon when required e.g. Physical assets.	Very poor	No spare capacity to make investments of any kind.
Insurance	No access to insurance of assets, either through exclusion or unaffordability.	Community access to affordable insurance schemes covering lives, homes and other property through market insurance or micro-finance schemes.	Very poor	No access to insurance. Too risky for private insurers to cover residents - crime, natural disasters and no means of repayment on policies.
Business and industry	Lack of local	Presence of	Fair	Many locally

	Very poor	Very good		
	business and entrepreneurs within the community.	thriving local business and entrepreneurs.		run small businesses such as shops, bars and beauty salons.
Environmental assets				
Ownership of natural resources	No access to or ownership of natural assets. Community has no say in use and distribution of natural assets.	Equality of access to natural resources. Community involvement in decision making surrounding natural resources.	Very poor	Huge inequality of natural resources. Community have to pay private firms for water, land (rent).
Human assets				
Local and traditional knowledge	No attention paid to local and traditional knowledge through consultation and planning of policies or projects.	Indigenous, traditional and informal communication. Consultation with stakeholders to understand local culture, practises and contexts. Community	Poor	Significant divides and tensions within the community between different tribes (Luo and Kikuyu), tenants and landlords, and employed and unemployed.

		experience of coping in previous crises.		
Skills	Community members lack skills to cope with shocks and stresses.	Community has skills to counter shocks and stresses, such as first aid, food distribution, self-assessment of preparation.	Poor	Much of the community is unskilled and do not have to spare capacity to prepare for predictable shocks and stresses.
Language competency	No common language spoken throughout the community, leading to difficulties in holistic consultation.	Community can communicate internally and externally in a common language such as English.	Poor	Very little English spoken. Different ethnic groups use different languages, making communication a challenge.
Health	Poor level of health within the community e.g. Diseases, water-born viruses.	Good general health within the community. Access to medical treatment. Services contributing to health such as sanitation and	Poor	No government hospitals or clinics within Kibera. Adequate medical care is provided by NGOs and churches.

drainage.

Education	No access to adequate education and training programmes.	Access to education and training programmes. Equity of educational opportunities	Very poor	No government schools within Kibera. Very low levels of education.

Social assets

	Very poor	**Very good**		
Community cohesion and cooperation	Segregation of groups within the community. Little community cohesion and 'togetherness'.	Undertakes mitigation activities to address social problems. Strong sense of community and place.	Poor	Divided community due to ethnic divides. Big problem with alcohol (Changaa) and drugs.
Religion	No presence of religious organisations of any faith within the community.	Adherence to religious groups, organisations or support groups (not necessarily the same religion).	Good	Strong adherence to religious groups but these differ with tribe. No majority common religion.
Community organisations	No presence of organisations (internal or external) that	Presence of community organisations capable of	Very good	NGO and religious organisations do a very good

provide support and help to community members.	managing shocks and stresses and provide support e.g. Local NGOs, community groups.	job of providing services that are lacking in the community - clinics, schools etc.

CAPACITIES

Category	Indicator(s)		Rating	Justification
Resourcefulness				
	Very poor	**Very good**		
Mobilises resources	No capacity to mobilise resources in times of emergency. No assistance from external actors.	Capacity to mobilise needed resources in emergencies. Can request assistance from a number of different actors when required.	Fair	There are many NGOs, charities and religious groups that assist in times of particular need. Very little help from government. Little community cohesion and organisation leads to limited foresight of shocks and stresses.
Visualise and act	No capacity for community to plan and act on the threat of future shocks and stresses.	Capacity of community to devise strategies to overcome shocks and stresses.	Poor	
Identify problems	No ability to foresee and identify severe problems affecting livelihoods.	Ability to prioritise problems affecting livelihoods and respond to them	Poor	Community is 'stuck' in poverty and lack the resources to

		accordingly.		improve their livelihoods.
Innovate	No diversity of skills and innovation within the community.	Community members employed in innovative and creative occupations e.g. Education, arts, music etc.	Very poor	Limited innovation is evident. Residents are either unskilled, unemployed or manage small retail businesses.
Coordinate	No coordination and cohesion within the community. Community lacks the will or ability to coordinate specific relevant tasks e.g. Communication, first aid etc.	Sufficient number of trained and organisational personnel and community members to carry out specific relevant tasks e.g. Communication, first aid etc.	Fair	Large ethnic divide in community, however NGO, charity and church groups assist in this regard.

Adaptive and flexible

	Very poor	**Very good**		
Adapt to long-term trends	No capacity or ability to recognise and adapt to foreseen long-term trends.	Ability to adapt over the long-term to changes which contribute to uncertainty e.g. Environment, political and social changes. Ability to make active choices about alternative livelihood strategies.	Poor	Very limited power to influence change in the community. With no land tenure there is little investment in infrastructure and low levels of ownership.

Convert assets	No capacity to concert assets for other uses. Assets are so limited that they are relied upon to merely survive.	The ability to convert assets and evolve towards new forms or functions. Key assets are distributed so that they are not all affected by a single shock or stress at one time. Multiple ways of meeting a given need.	Poor	Very limited income means residents simply survive day to day but cannot move forward and move towards new functions.
Respond to change	Community has no capacity to respond to change due to limited resources.	Community is flexible and can proactively respond to change e.g. Able to take a job with lower pay than skills.	Good	Residents have option to be flexible but often aren't. High levels of alcoholism and drug use cause a lack of desire to be employed.

Learn

	Very poor	**Very good**		
Build on past experiences	No attention paid to past experiences and knowledge of shocks and stresses e.g. Rebuilding on flood plains etc.	Ability to integrate past experiences of shocks and stresses with current knowledge to understand the dangers in the environment.	Poor	Due to high density there is limited space to relocate dwellings within Kibera. No choice but to rebuild in hazard-prone areas and to continue using kerosene lamps.

Assess, manage and monitor risks	No will, ability or capacity to actively monitor risks within the community e.g. Disease, substance abuse, natural disasters.	Levels of awareness about maintaining good levels of hygiene and sanitation practices and observing natural changes or environment to provide early warning.	Very poor	Significant lack of awareness about the dangers of poor hygiene, sanitation and diseases such as HIV. No early warning systems in place.
Build back	No capacity to adapt to changes following a shock or stress.	Ability to build back after a disaster and work towards ensuring that vulnerabilities continue to be reduced for the future. More safety and resilience means less vulnerability.	Poor	Residents build back after shocks, however do not have the resources to improve their dwellings to respond to known hazards. Building materials are often stolen from destroyed dwellings.

QUALITIES

Category	Indicator(s)		Rating	Justification
Strong/robust				
	Very poor	**Very good**		
Withstand external pressure or	No capacity or ability of assets/resources	Assets/resources that are robust and can withstand external	Poor	Community has little power to influence change

	Very poor	Very good		
demands	to withstand external pressures or demands.	pressures or demands without loss of function.		or communicate their concerns with government.
Strong	Poor construction leaves infrastructure vulnerable to failure.	Well constructed infrastructure that can withstand shocks and stresses. Adequate building codes that are adhered to.	Poor	Very poor infrastructure provision. No building codes imposed on construction in Kibera.
Increased size	No ability to rapidly increase contingency funds to the community.	Emergency contingency funds and stocks that can be made available quickly to those in need, with established procedures for releasing them.	Fair	NGOs, charities and religious groups support residents in need. No extra capacity available to residents themselves.

Well located

	Very poor	Very good		
Geographically distributed	Assets are concentrated in one location and vulnerable to total destruction.	Assets are distributed so that they are not all affected by a single event.	Poor	Assets are not distributed. Fires and floods often cause complete loss of assets.
High risk areas	Assets are located within high risk areas (e.g. Flood plains).	Assets are located outside of high risk areas (e.g. Flood plains) so as to	Poor	High density housing in flood risk areas. Periodic flooding

	Very poor	Very good	Very poor	
		decrease the risk of degradation.		causes destruction.
Diverse				
Diversified livelihood opportunities	Limited range of livelihood opportunities within the community.	Community able to meet its needs in a variety of ways e.g. Social (variety of internal organisation) economic (multiple employers and employment opportunities), environmental (different groups in an ecosystem).		Very few employment opportunities. The majority of the employed work as unskilled labourers in manufacturing sector.
Redundant				
Coping capacity	No spare capacity of resources to rely on during particular times of need.	Resources are able to offer spare capacity to accommodate extreme pressure so that alternative options and substitutions are available under stress.		No spare capacity due to low earnings.
Equitable				
Ownership	No equality in ownership of	Assets are shared equally and allow	Very poor	No land ownership.

assets.	inclusive access and ownership.		Resources such as water and electricity are provided by private sector at large cost.

Assessment after the KENSUP intervention:

EXTERNAL RESOURCES

Category	Indicator(s)		Rating	Justification
Connections and information				
	Very poor	**Very good**		
Transportation and infrastructure	No safe, affordable transport provision. Residents have to walk long distances to get to places of work	Adequate provision of public transportation and access e.g. Busses, trains etc.	Good	Busses are available but there is no transport infrastructure within Kibera. Adequate access to trains.
Communication and information	No open dialog between the community and authorities. Community is not consulted	Established social information and communication channels; vulnerable people not isolated. Community	Fair	Broad surveying of perceived needs was conducted prior to project implementation, however KENSUP was criticised for

	regarding decisions made prior to projects.	exchanges information with government and other actors. Community receives early warning about shocks.		a lack of holistic consultation with various groups within the community.
Technical advice	Community has no access to professional assistance for projects that they wish to undertake.	Community has access to technical advice and support from external agencies e.g. Infrastructural repairs or retrofitting.	Fair	KENSUP employed local labour, allowing skill sharing between technical professionals and residents.

Services

	Very poor	**Very good**		
Municipal services	Total lack of municipal services e.g. Waste collection, policing etc.	Functioning municipal services e.g. waste collection, policing etc.	Fair	Toilet blocks constructed that greatly improved sanitation. Door-to-door waste collection scheme put in place.
Medical care	No external provision of medical care and emergency	Access to external provision of medical care and emergency	Poor	A community youth and resource centre was constructed to dispense basic

	response strategies. Total lack of hospitals and doctors servicing the community.	response. Sufficient number of hospitals and doctors servicing the community.		medicine. No clinics or hospitals were built. Government do provide free ARVs for HIV positive members.
Government funding	No provision of external funding for community projects and upliftment.	Government and other external sources provide adequate funding for the bettering of community livelihoods.	Good	Kenyan government partnering (and funding) with UNISDR shows a commitment to improving the lives of the community.
Natural resources				
	Very poor	**Very good**		
Land	Community has no rights or deeds to land.	Security of land tenure given to the community by authorities.	Very poor	KENSUP did not secure land tenure of any kind for the residents.
Water	No provision of clean, safe drinking water.	Adequate access to clean, safe drinking water provided by municipal infrastructure.	Fair	Stand pipes were installed providing clean, safe drinking water within the community. The community was pleased with this but still no

Category	Indicator(s)		Rating	Justification
Ecosystem	No external protection of environment including biodiversity, water and air.	External protection of ecosystem which provides clean water, air and a stable climate.	Fair	household water connections. KENSUP aimed to protect natural resources but reducing sewage discharge into Nairobi dam. No measures were taken to enhance biodiversity.

ASSETS

Category	Indicator(s)		Rating	Justification
Physical assets				
	Very poor	**Very good**		
Public facilities	No provision of public facilities or public facilities have fallen into disrepair.	Adequate public facilities and infrastructure that have been maintained and protected through retrofitting, upgrading and rebuilding.	Fair	Construction of community youth and resource centre. Plans for more community centres and parks. 1000 new households electrified.
Housing	Housing is structurally inadequate and	Housing is structurally sound (not	Poor	1000 households relocated to

	Very poor	Very good		
	unsafe e.g. Constructed from corrugated iron and other scrap materials.	mobile).		improved housing construction but their rents have increased. KENSUP did not aim to improve community housing throughout. Internal roads and pedestrian paths constructed for better access within the community.
Transport infrastructure	Lack of road and rail servicing the community.	Adequate transport infrastructure e.g. road, rail and bus.	Good	
Stockpiles for emergencies	No spare capacity to provide emergency relief in a time of crisis.	Access to stockpiles of emergency food and medical supplies, as well as access to emergency shelter.	Poor	Very little provided by government. NGOs and charities assist with disaster relief to some extent.
Economic assets				
	Very poor	**Very good**		

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Livelihood assets	Inequality in distribution of wealth and livelihood assets in community.	Equitable distribution of wealth and livelihood assets in community (DIFD Livelihoods Framework).	Fair	Effort made to reduce victimisation of residents by landlords and resource owners.
Employment and income	Lack of economic activity and employment opportunities within or surrounding the community.	Good levels of local economic activity, sustainability in economic activity and employment. People can take alternative employment.	Fair	Access and improved safety has greatly improved economic activities within the community. Skills have been transferred through the community-led construction process.
Savings and contingency	Community members have little or no savings and are excluded from financial	Households or community has savings or can access grants and loans. Access to micro-	Fair	Plan for communal savings cooperative and microfinance

	support.	finance schemes.	to be established in the near future. Investment and assets should increase with increased economic activity and bettering of livelihoods.
Investment	No investment contingency that can be used in times of need.	Households or community have investments that they can rely upon when required e.g. Physical assets.	Poor
Insurance	No access to insurance of assets, either through exclusion or unaffordability.	Community access to affordable insurance schemes covering lives, homes and other property through market insurance or micro-finance schemes.	Very poor	No access to insurance. Too risky for private insurers to cover residents - crime, natural disasters and no means of repayment on policies. KENSUP did not tackle this issue.
Business and industry	Lack of local business and entrepreneurs	Presence of thriving local business and	Good	Many locally run small businesses

within the community.	entrepreneurs.			such as shops, bars and beauty salons. Improving with improved access and investment.

Environmental assets

	Very poor	Very good		
Ownership of natural resources	No access to or ownership of natural assets. Community has no say in use and distribution of natural assets.	Equality of access to natural resources. Community involvement in decision making surrounding natural resources.	Fair	Greatly improved access to natural resources. Community consulted extensively with regards to project scope.

Human assets

	Very poor	Very good		
Local and traditional knowledge	No attention paid to local and traditional knowledge through consultation and planning of policies or	Indigenous, traditional and informal communication. Consultation with stakeholders to understand local	Good	Extensive consultation with community members. Allowed them to rank the needs and

	projects.	culture, practises and contexts. Community experience of coping in previous crises.	deprivations of the community. Not everyone was consulted but there was a good effort made in this regard.
Skills	Community members lack skills to cope with shocks and stresses.	Community has skills to counter shocks and stresses, such as first aid, food distribution, self-assessment of preparation.	Fair	Improved skills from hiring of local employment, particularly in construction techniques.
Language competency	No common language spoken throughout the community, leading to difficulties in holistic consultation.	Community can communicate internally and externally in a common language such as English.	Good	Surveys were done verbally in either English or Kiswahili.
Health	Poor level of health within the community e.g. Diseases, water-borne	Good general health within the community. Access to medical	Good	Greatly improved community health through

	viruses.	treatment. Services contributing to health such as sanitation and drainage.		tackling the serious issue of unsafe sanitation. Reduction in water-borne viruses and diseases.
Education	No access to adequate education and training programmes.	Access to education and training programmes. Equity of educational opportunities	Poor	No government schools within Kibera. Very low levels of education. Improved awareness about right to education.
Social assets				
	Very poor	**Very good**		
Community cohesion and cooperation	Segregation of groups within the community. Little community cohesion and 'togetherness'.	Undertakes mitigation activities to address social problems. Strong sense of community and place.	Fair	Reports of improved community cohesion stemming from the consultation process, as well as a more secure sense of place.

| Religion | No presence of religious organisations of any faith within the community. | Adherence to religious groups, organisations or support groups (not necessarily the same religion). | Good | Strong adherence to religious groups but these differ with tribe. No majority common religion. |
| Community organisations | No presence of organisations (internal or external) that provide support and help to community members. | Presence of community organisations capable of managing shocks and stresses and provide support e.g. Local NGOs, community groups. | Very good | NGO and religious organisations do a very good job of providing services that are lacking in the community - clinics, schools etc. |

CAPACITIES

Category	Indicator(s)		Rating	Justification
Resourcefulness				
	Very poor	**Very good**		
Mobilises resources	No capacity to mobilise resources in times of emergency. No assistance from external actors.	Capacity to mobilise needed resources in emergencies. Can request assistance from a number of	Fair	There are many NGOs, charities and religious groups that assist in times of particular need.

	Very poor	Very good	Rating	
		different actors when required.		Very little help from government.
Visualise and act	No capacity for community to plan and act on the threat of future shocks and stresses.	Capacity of community to devise strategies to overcome shocks and stresses.	Fair	KENSUP instigated various training programmes, however there is still a limited capacity to act.
Identify problems	No ability to foresee and identify severe problems affecting livelihoods.	Ability to prioritise problems affecting livelihoods and respond to them accordingly.	Fair	Clear evidence that the community can identify problems through the consultation process.
Innovate	No diversity of skills and innovation within the community.	Community members employed in innovative and creative occupations e.g. Education, arts, music etc.	Poor	No indication that innovation has improved, however new skills have been passed on to key groups.
Coordinate	No coordination and cohesion within the community. Community lacks the will or ability to coordinate specific relevant tasks e.g. Communication, first aid etc.	Sufficient number of trained and organisational personnel and community members to carry out specific relevant tasks e.g. Communication, first aid etc.	Good	Training programmes run on organisation, planning and management.

Adaptive and flexible

Very poor	**Very good**

	Very poor	Very good		
Adapt to long-term trends	No capacity or ability to recognise and adapt to foreseen long-term trends.	Ability to adapt over the long-term to changes which contribute to uncertainty e.g. Environment, political and social changes. Ability to make active choices about alternative livelihood strategies.	Fair	Community have been given a greater voice with which to voice concerns to the Kenyan government.
Convert assets	No capacity to concert assets for other uses. Assets are so limited that they are relied upon to merely survive.	The ability to convert assets and evolve towards new forms or functions. Key assets are distributed so that they are not all affected by a single shock or stress at one time. Multiple ways of meeting a given need.	Poor	Very limited income means residents simply survive day to day but cannot move forward and move towards new functions.
Respond to change	Community has no capacity to respond to change due to limited resources.	Community is flexible and can proactively respond to change e.g. Able to take a job with lower pay than skills.	Good	Residents have option to be flexible but often aren't. High levels of alcoholism and drug use cause a lack of desire to be employed.
Learn				
	Very poor	**Very good**		

Build on past experiences	No attention paid to past experiences and knowledge of shocks and stresses e.g. Rebuilding on flood plains etc.	Ability to integrate past experiences of shocks and stresses with current knowledge to understand the dangers in the environment.	Fair	Community clearly able to identify the threats to their livelihoods. Greater capacity to prioritise shocks and stresses through training programmes.
Assess, manage and monitor risks	No will, ability or capacity to actively monitor risks within the community e.g. Disease, substance abuse, natural disasters.	Levels of awareness about maintaining good levels of hygiene and sanitation practices and observing natural changes or environment to provide early warning.	Fair	Training programmes surrounding sanitation best practise and WASH principles have led to increased ability to manage risks relating to health and hygiene.
Build back	No capacity to adapt to changes following a shock or stress.	Ability to build back after a disaster and work towards ensuring that vulnerabilities continue to be reduced for the future. More safety and resilience means less vulnerability.	Poor	Residents build back after shocks, however do not have the resources to improve their dwellings to respond to known hazards. Building materials are often stolen from destroyed dwellings.

QUALITIES				
Category	**Indicator(s)**		**Rating**	**Justification**
Strong/robust				
	Very poor	**Very good**		
Withstand external pressure or demands	No capacity or ability of assets/resources to withstand external pressures or demands.	Assets/resources that are robust and can withstand external pressures or demands without loss of function.	Fair	Improved infrastructure is more robust - toilet blocks and roads etc. Housing is still an issue.
Strong	Poor construction leaves infrastructure vulnerable to failure.	Well constructed infrastructure that can withstand shocks and stresses. Adequate building codes that are adhered to.	Fair	Construction overseen by professionals suggests that it would be strong.
Increased size	No ability to rapidly increase contingency funds to the community.	Emergency contingency funds and stocks that can be made available quickly to those in need, with established procedures for releasing them.	Fair	NGOs, charities and religious groups support residents in need. No extra capacity available to residents themselves.
Well located				
	Very poor	**Very good**		
Geographically distributed	Assets are concentrated in one location and	Assets are distributed so that they are not all affected by a single	Poor	Assets are not distributed. Fires and floods

	Very poor	Very good		
	vulnerable to total destruction.	event.		often cause complete loss of assets.
High risk areas	Assets are located within high risk areas (e.g. Flood plains).	Assets are located outside of high risk areas (e.g. Flood plains) so as to decrease the risk of degradation.	Poor	High density housing in flood risk areas. Periodic flooding causes destruction.
Diverse				
	Very poor	**Very good**		
Diversified livelihood opportunities	Limited range of livelihood opportunities within the community.	Community able to meet its needs in a variety of ways e.g. Social (variety of internal organisation) economic (multiple employers and employment opportunities), environmental (different groups in an ecosystem).	Fair	Increased number of employment opportunities as well as new skills acquired.
Redundant				
	Very poor	**Very good**		
Coping capacity	No spare capacity of resources to rely on during particular times of need.	Resources are able to offer spare capacity to accommodate extreme pressure so that alternative options and	Very poor	No spare capacity due to low earnings. This could increase in the future with

	substitutions are available under stress.			greater earnings and job creation.
Equitable				
	Very poor	**Very good**		
Ownership	No equality in ownership of assets.	Assets are shared equally and allow inclusive access and ownership.	Very poor	No change in land ownership rights.

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Highlights

- There is a need for a generic technique to be applied for the assessment of localised infrastructure at community level.
- The paper outlines the development of a framework which is then applied in a slum in Kenya
- The added value of the framework discussed in this article is its application to informal settlements and the ease of use with limited data.