An Analysis of Stakeholders' Perceptions on Urban Water Erosion in Windhoek, Namibia

Rosemary N. Shikangalah[1] University of Namibia
Eva N. Paton[2] Technische Universität Berlin, Germany &
Florian Jeltsch[3] University of Potsdam, Germany

Abstract

This study aimed at understanding the perceptions of stakeholders on urban water erosion in a dryland city - Windhoek (Namibia) - by interviewing 41 stakeholders using semi-structured questionnaires. Stakeholders' perceptions were analysed by addressing their understanding of water erosion dynamics, their perceptions with regards to the causes and the seriousness of erosion damages, and their attitudes towards the responsibilities of urban erosion prevention and damages. The results indicated that there is less awareness of the process as a phenomenon; instead there is more awareness of erosion damages and the factors contributing to the damages. About 69% of the stakeholders considered erosion damages to be ranging from moderate to very serious. However, there were notable disparities between the private householders and public authority groups. The private householders and local authority sectors pointed fingers at each other as regards responsibility for erosion damage payments and for putting up prevention measures. The reluctance to take responsibility could undermine any effort to minimise erosion in urban areas and create a predicament for areas affected, especially in the informal settlements where land management is not carried out by the local authority and land is not owned by the occupants.

[1] Dr Rosemary N. Shikangalah is a Senior Lecturer in the Department of Geography, University of Namibia, Namibia. Her research interests are rural and urban socio- eco-hydrological challenges and the influence of climate change on geo-biophysical cycles with a focus on soil conditions and related ecological dynamics. Email: rshikangalah@unam.na

[2] Prof. Dr. Eva N. Paton is the Head of the Department of Ecohydrology and Landscape Assessment, Technische Universität Berlin, Germany. Research Interests: Ecohydrological monitoring, scaling and modelling, urban eco-hydrology, socio-eco-hydrology, Analysis of connectivity, self-organization and complex systems, analysis of land degradation, erosion and land use changes, analysis of soil-plant-water feedback. Email: eva.paton@tu-berlin.de

[3] Prof. Dr. Florian Jeltsch is the Head of Department of Plant Ecology and Conservation Biology at University of Potsdam, Germany. Research Interests: Spatial ecology: linking individuals, populations, communities and landscapes, dryland ecology, impact of land use and environmental change on biodiversity dynamics. Email: jeltsch@uni-potsdam.de

Correspondence concerning this article should be addressed to Dr Rosemary N. Shikangalah, Department of Geography, University of Namibia, Namibia. Email: rshikangalah@unam.na

***Keywords**: stakeholder analysis, stakeholder perception, water erosion, Windhoek erosion, urban erosion*

Water erosion is one of the major contributing factors to land degradation worldwide. The continuous increase in global population and the consequent use of vast lands intensifies the process of water erosion (Cantón et al., 2011; Pimentel & Kounang, 1998; Pimentel, 2006). For decades this problem was mostly recognised as a challenge for agricultural areas (Garcia-Ruiz et al., 2010; Lal, 1998; Nearing, Pruski & O′ Neal, 2004; Prasannakumar, Vijith, Abinod & Geetha, 2012). However, this phenomenon has increasingly become a prevalent challenge in urban environments as these areas are becoming increasingly densely populated. Currently, more than half of the world's population lives in urban areas and the number is expected to further increase (Huang, Yeh & Chang, 2010; Haas & Ban, 2014; Pickett et al., 2008).

The demand for more land to cater for infrastructure development and other social and economic activities of humans reduces the urban pervious surfaces; thereby restricting water to specific flow paths and increasing surface overland flow which often results in accelerated water erosion (Cantón et al., 2011; Merz, Kreibich, Schwarze & Thieken, 2010; Strahler, 2010). The consequences of urban erosion have a major impact on both the urban environment and infrastructure (Harris & Adam, 2006; Sutherland & Tolosa, 2000). Such consequences include the blocking of sewerage systems, damages to houses and streets, transport contaminations and the pollution of water bodies such as dams and aquifers (Aksoy & Kavvas, 2005; Bong, Lau & Ghani, 2011; Gaffield, Goo, Richards & Jackson, 2003; Shuster, Bonta, Thuston, Warnemuende & Smith, 2005).

Until recently, urban water erosion has been largely studied in temperate climatic regions and very few studies have addressed urban erosion in dryland regions, particularly in Africa (Shikangalah, Jeltsch, Blaum, & Mueller, 2016). This holds true despite the high rate of urbanisation in developing countries (Cohen, 2006; Duranton, 2015; Huang et al., 2010) and the susceptibility of dryland regions to urban water erosion (Cornelis, 2006; Ligonja & Shrestha, 2013; Tooth, 2000; Vásquez-Méndez, Ventura-Ramos & Dominguesz-Cortázar, 2011).

However, a recent study of the real extent of urban water erosion in Namibia's capital city, Windhoek, demonstrated that water erosion is indeed a serious problem in the city with 56% of the city area affected and erosion was strongly associated with vegetation cover and land management (Shikangalah, Paton, Jeltsch & Blaum, 2017). Although understanding of stakeholders' perception is one of the gaps in urban water erosion studies, the aim of this study originated however from several contradictory messages which the researchers got from both private land owners and public officers during a fieldwork in 2015 for the quantification of erosion features (Shikangalah et al., 2017). A number of stakeholders did not acknowledge the

existence of any water erosion damages even though severe damages at communal and private infrastructure were evident. This, therefore, justified the need for further investigations into the underlying factors which influence water erosion specifically to understand the communities' views rather than focussing more on the environmental aspects. Failure to appreciate the linkages between the understanding of the communities (both private and public sectors) and urban water erosion might prevent the development of appropriate environmental policies and land management guidelines. Consequently, this study attempts an understanding of the perceptions and level of awareness of water erosion occurrences and its effects through a consideration of different stakeholder groups from a dryland city.

The researchers hypothesised that there is probably little awareness of the phenomenon of water erosion across all sectors of stakeholders (land owners, authorities, companies) especially among decision-makers and implementers. However the researchers expected higher levels of awareness of a certain type of damage on houses, yards, paths, parking lots and roads such as rills, gullies and cracks on houses. The researchers also believed that the understanding of water erosion and its underlying mechanisms are very patchy and site-specific. And, lastly, the researchers hypothesized that there is no clear understanding on who is responsible for the implementation of erosion prevention control measures (e.g. house owners or city authorities), which is particularly pronounced for inhabitants of informal settlements. We envisaged that the stakeholder groups will not accept responsibility regarding prevention control and payments for damages (i.e. the house owners group will state that it is the responsibility of the municipality group, and vice-versa).

To test these ideas, objectives were formulated which aimed at: (1) determining stakeholders' awareness on the severity and locations of soil erosion; (2) examining perceived responsibilities for damages and prevention measures within the different groups of stakeholders; and (3) determining stakeholders' understanding and knowledge of natural processes and landscape features that result in water erosion.

Literature review

More than half of the world's population is currently residing in urban areas and further increase is anticipated through urbanisation (Haas & Ban, 2014; Huang et al., 2010; Pickett et al., 2008). Urbanisation is intensified by many factors including political instabilities and the increased effects of climate change on natural resources leading to high rates of rural-urban migration (McLeman & Smit, 2006; Portnov & Paz, 2008). As a result of rapid population growth in urban areas (Kötter & Friesecke, 2007; United Nations, 2012), there is a continuous demand of land for settlement development accompanied by the necessities of infrastructure and services to cater for the population's growing socio-economic needs (Shuster et al., 2005).

Consequently, massive of vegetation cover are continuously cleared off the land surface and replaced with the impermeable surfaces such as buildings, roads, drainage systems and pavements surfaces (Shuster et al., 2005; Strahler, 2010). Such structures restrict the movements of water to particular flow paths. This subsequently amplifies the amount of water runoff and accelerate water erosion leading to numerous problems in urban areas. Presently, water erosion appears to be largely recognised for its contribution to soil degradation and the resultant low productivity in agricultural activities (Cantón et al., 2011; Fu et al., 2009; Lal, 2001; Nearing et al., 2004; Pimentel, 2006; Pimentel & Kounang, 1998; Prasannakumar et al., 2012).

Erosion mostly occurs in dryland climatic regions. Dryland covers more than 40% of the global land surface and is home to more than 30% of the world's population (Feng & Fu, 2013; Reynolds et al., 2007; Verón, Paruelo & Oesterheld, 2006). These regions are persistently affected by soil water erosion due to the scarcity of vegetation cover, prolonged drought and intense rainfall events (Ligonja & Shrestha, 2013; Tooth, 2000; Vásquez-Méndez et al., 2011). Soil erosion is a process of detachment, transportation and deposition of soil materials by wind or water (Aksoy & Kavvas, 2005; Lal, 2001; Morgen, 1995; Vreiling, 2006). Where water is the agent, soil is exposed to raindrops and this results in the removal of topsoil which consequently forms soil erosion features (Le Roux, Morgenthal & Malherbe, 2008; Pimentel & Kounang, 1998). Billions of hectares in various climatic regions have been affected by water erosion (Ananda & Herath, 2003; Pimentel & Kounang, 1998).

While this has been true mostly for agricultural areas, the phenomenon has increasingly become a problem for urban environments as urban areas become centres of rapid population growth. Urban water erosion causes damages to houses and roads, clogs drainage systems, contaminates and deposits silt in reservoirs while also reducing ground water recharge resulting in degradation of ecological functions (Bong et al., 2011; Gaffield et al., 2003; Merz et al., 2010; Shuster et al., 2005; Strahler, 2010; Wei Chen, Yang, Fu & Sun, 2012). Proper planning and environmental management is not only essential to ensure that urban ecosystems can cope with the high population without imposing irreversible damage on the environment but it is also necessary to ensure that urban centres are good enough locations for future residency (Pickett et al., 2008).

The studies of water erosion dynamics in urban areas is based on environmental attributes such as land use, topology, and vegetation cover (Shikangalah, Jeltsch, Blaum & Mueller, 2016). Since water erosion is accelerated by human activities, understanding the perceptions of communities affected by erosion processes should be fundamental for developing prevention and control measures of water erosion damages. Unfortunately, consultations with the affected communities are not commonly included in studies which deal with the impacts of water erosion (Reidsma, Ewert, Lansink & Leemans, 2010). On the contrary, such consultative efforts

are essential for developing more practical and consensus solutions (Lange, Siebert & Barkmann, 2015; Mitter, Kirchner, Schmid & Schoenhort, 2014).

The lack of inclusion of the affected communities in the studies explains why policy interventions often fail (Mutekanga, Kessler, Leber & Visser, 2013). To overcome this shortfall, some studies on water erosion are increasingly employing stakeholder analysis methodologies to develop effective solutions (Reed, 2008; Stanghellini & Collentine, 2008). These, however, have been carried out mainly in agricultural environments (Evans, 2002; Heitz, Spaeter, Auzet & Glatron, 2009; Izazola, Martínz & Marquette, 1998; Okoba & de Graaff, 2005; Zegeye, Steenhuis, Blake, Kidnau, Collick & Dadgari, 2010) and hardly explored urban areas. Yet engaging the affected communities helps to understand the behaviour that influences the total environmental system (Agle & Mitchell, 1999; Cordono, Frieze & Ellis, 2004). This contributes to the generation of applicable solutions for reducing erosion risks (Heitz et al., 2009; Mitter et al., 2014; Mutekanga et al., 2013) particularly for the design of control measures (Amsalu & de Graaff, 2006). Currently, the dynamics of water erosion are inadequately studied and barely understood in urban areas (Anigbogu, 2001; Le Roux et al., 2008; Wei et al., 2012; Yair & Raz-Yassif 2004).

Material and Methods

Study Context

This case study is based in Windhoek, the capital city of Namibia in Southern Africa. Being the only city in the country, Windhoek is the centre of attraction for economic-related activities and it accommodates migrants from both rural areas and other smaller urban areas. Consequently, the city is now home to about 15% of the Namibian population (National Planning Commission 2012; Pendleton et al. 2014), with a population growth rate of 5% (Frayne, 2007; Lahnsteiner & Lempert, 2007; Pendleton, Crush & Nickanor, 2014). Windhoek is a dryland city that is affected by water erosion as a result of climatic conditions and land use pressure from urban developments (Gray, Keating, Moody, Swan & Keating, 2008; Greunen, 2013; Mapani & Schreiber, 2008; Shikangalah et al., 2017). Although the scarcity of vegetation cover is a result of dryland conditions, the clearance of vegetation for housing constructions (Figure.1) and the use of timber and firewood exacerbates the susceptibility of the soil to water erosion, especially in the informal settlements (Labbe, Mcbride & Ray, 2006).

a)

b)

Figure 1: Examples of erosion damages to houses

Data Collection and Analysis

The target stakeholder groups of this study included: (1) the decision makers from local authorities (i.e. government officials from the Ministry of Agriculture, Water and Forestry, the Ministry of Environment and Tourism, the Ministry of Regional and Local Government, Housing and Rural Development; officials of the City of Windhoek municipality from various sections such as environmental management, storm water, Geographical Information System (GIS) specialists, urban planning and disaster management section); politicians (i.e. councillors of the high, middle and low income constituencies); (2) private householders who are members of the local community that own properties in formal and informal settlements; (3) developers sector (e.g. personnel from construction companies): and (4) other sectors (Table 1). The informal settlements are described as areas where people settle without legal rights of ownership (UN-Habitat, 2015; Wakhungu, Huggins, Nyukuri & Lumunda, 2010).

Table 1: *Stakeholder distribution*

Stakeholders sectors	**Represented groups (**66% males, 34% female**)**	**Interviewed Stakeholders**	
		Total number (41**)**	**Percentage (%)**
Public authorities	Municipal officials Government officials Councillors (politicians)	7 6 3	**39**
Private households	Households from low-income areas Households from middle-income areas Households from high-income areas	5 5 5	**37**
Developers	Private construction companies	5	**12**
Others	NGO (UN-Habitat) Private company (Namwater) Academics	1 1 3	**12**

A total of 41 stakeholders were interviewed face-to-face using a semi-structured questionnaire. The instrument allowed the exploration of emergent themes and ideas during the interview (Galletta, 2013; Heitz et al., 2009). It further allowed flexibility, catered for professional viewpoints and also enabled the respondents to reflect on the issues adequately (Lange et al., 2015). A snowball method was used to identify the stakeholders. In this method, the participants are generally identified through chain-referral sampling as recommended by the participants who were contacted first (Heckathorn, 2011). The use of a snowball approach eases the process of identifying relevant stakeholders, thereby reducing time constraints and reducing bias in identifying the specific samples of stakeholders for the analysis (Prell, Hubacek & Reed, 2009; Varvasovszky & Brugha, 2000). The data collection was conducted over two months in 2015 (October and November). A number of topics were covered to address the stated research objectives on stakeholders' awareness, perception of responsibilities and stakeholders' understanding of erosion analysis. Table 2 provides the topics and a summary of the main questions. Data were analysed using frequencies (percentages) only, taking after many studies that are presented in this manner in various disciplines (See Glasgow, Langaigne, Thomas, Harvey & Campbell, 2018; Karami, Shobeiri, Jafari, & Jafari, 2017; McAdams, Rehr, Kobayashi, & DeArman, 2019).

Table 2 *Areas of enquiry, topics and main questions*

Areas of enquiry	Topics	Main questions
Stakeholders' awareness	Risk of erosion in Windhoek Most affected areas Seriousness of damages	How do you rank the risk for erosion in Windhoek? Which areas are most affected and why? Do you think that these damages are serious or not?
Responsibilities for damage and prevention measures	Payment for damages Suggestions for tackling the damages Payment for prevention measures Responsibility for prevention measures Suggestions on prevention measures Challenges of controlling erosion	Who do you think should pay for the damage caused by erosion? Would you have any suggestions on how to tackle the problem of damages? Who should pay for prevention measures? Who do you think is responsible for prevention measures and why? What do you suggest the responsible people for prevention measures should do? What are the biggest challenges in controlling erosion?
Stakeholders' understanding of water erosion dynamics	Contributing factors Role played by factors	Do you think these factors contribute to erosion? In which way do they play a role in erosion?

Interviews lasted between 15 and 30 minutes and they were recorded and then transcribed. The transcripts were then coded to form categories (Galletta, 2013; Magnusson & Marecek, 2015). Short phrases were formulated first from the participants' answers and then further refined to produce more specific or more focused codes (tags). To ensure that all content was captured, transcribed and coded correctly, the researchers repeatedly went back to the initial answers and at times to the recordings. The codes were then grouped into four main analytical categories that were guided by the objectives of the research. Categories include stakeholders': (1) water erosion awareness; (2) experiences with the damages; (3) perception of responsibility with regards to damage: (4) responsibility for prevention measures: (5) understanding influencing factors: and (6) perceptions of the influencing factors. The succeeding result section is presented in accordance with these analytical categories.

Results

The analysis yielded three analytical categories to which the stakeholders' statements were allocated: (i) awareness of water erosion: (ii) perceptions regarding responsibility: and (iii) their understanding of the underlying processes of water erosion.

Assessment of Stakeholders' Awareness of Water Erosion

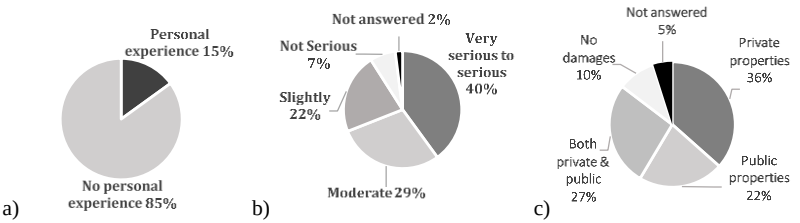

Figure 2: Results of stakeholders' views regarding their: (a) personal experience with erosion damages: (b) perceived seriousness of erosion damages: and (c) where most damages are seen in Windhoek

The interviewees displayed ambivalence on the extent and significance of water erosion. Whereas the majority of the interviewees said that they did not have direct experiences with erosion damages (Figure 2a), 69 % of the interviewees considered the damages due to erosion to be moderately serious to very serious (Figure 2b). The highest level of significance (very serious to serious) was expressed mostly (58%) by private households; only 24% of the public authority sector supported this view while the opposite percentage was expressed for the moderate level. In contrast, 29% of the interviewees indicated that the damages are less serious with 22% indicating "slightly serious" and 7% indicating "not serious". This was expressed by five developers, three private householders and four public authority respondents. People from this latter group even entirely denied the existence of water erosion as a problem for the City of Windhoek. As one interviewee stated (councillor); "As far as I know we do not have any experience in connection with water erosion problems or anything like that …; there is no report on that whatsoever." Another interviewee (municipality group) stated; "I am in this field for a long time … and there are no problems resulting from water erosion". Lastly, up to 36% indicated that most of the damages are seen on private properties and only 22% indicated the existence of the phenomenon on public properties (Figure 2c).

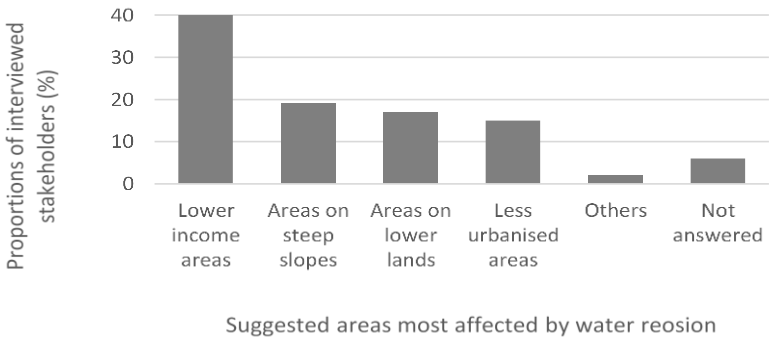

Figure 3: Results of stakeholders' interviews on the types of areas that are thought to be affected most by water erosion in Windhoek

Regarding the location of erosion (Figure 3), 40% of the respondents thought that most of the affected sites are situated in low income settlements including informal settlements in areas such as Okuryangava and Wanaheda (Figure 8). The stakeholders indicated that the occurrence of erosion in these settlements was due to inadequate infrastructure, lack of basic services and the usage of low quality building materials. In addition, 15% of the respondents thought that the urbanised areas will be more affected, thus referring to the damages again. Additional reasons adduced include factors such as poor ground conditions and little vegetation cover. One stakeholder (from the municipality group) stated that: "In these areas, they don't have trees, there is nothing binding the soil." Other reasons included the lack of planning and land management and also that the houses were built in valleys and river banks. Considering the areas that the stakeholders pointed out and the reasons given, it shows that both respondent groups (40% and 15%) identify erosion in terms of damages.

A little over a third of the stakeholders (36%) thought that the affected areas are located within certain slope ranges. About 19% suggested that the cause is steep slopes which include townships of Kleine Kuppe, Ludwigsdorf, Klein Windhoek, Avis and Ausblick, where runoff generation is presumably high (Figure 8). In contrast, 17% thought that the most affected areas are in lower lands in townships such as Otjomuise, Goreangab and the western parts of Windhoek where larger amounts of headwater catchment accumulate. Whereas the former thought of erosion in terms of the slope, the later thought of it in terms of where water accumulates. This is corroborated by one of the interviewees who said that; "all the water from the higher parts ends up in these areas" and another stated that "there are more river beds and more water ends [up] there." Both groups therefore showed that they have some knowledge of water erosion in terms of its process. Overall, the responses

demonstrate that the majority (55%) of the stakeholders know about the damages caused by erosion rather than the erosion process itself.

Perceptions Regarding the Responsibilities of Damages and Prevention Measures

Many stakeholders perceived the damages caused by water erosion as very serious to moderately serious (Figure 2a). With such serious view of the damages, the question of responsibilities was prompted with regards to payments for the damage and implementation of preventive measures. This section highlights the views of the stakeholders with regards to the question as to who should be held accountable.

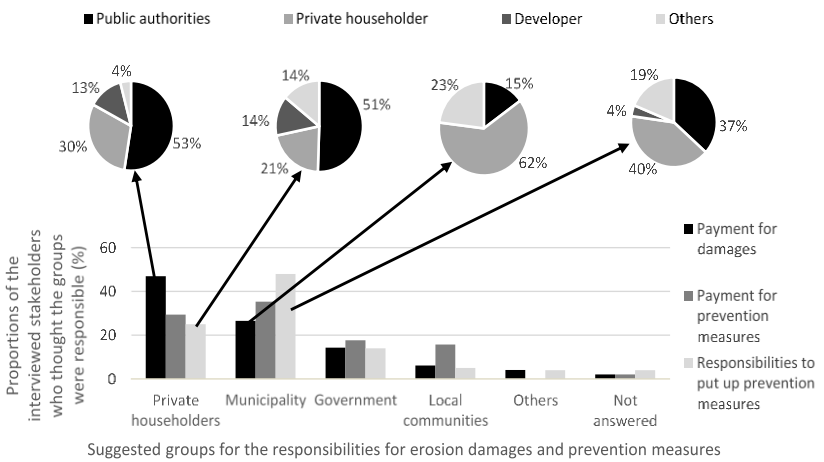

Figure 4: Groups which were held responsible for erosion damage and prevention measures; the pie graphs show the percentages of the 4 stakeholder sectors who hold this opinion

The interviewees generally felt that mostly the private households are to pay for erosion damage (Figure 4). The reasoning came down to the fact that they own the properties or the piece of land affected. However, fewer interviewees stated that the private households are responsible for paying or putting up prevention measures. Here, the majority (48%) stated that the municipalities should be responsible for putting up prevention measures. However, there was no clear picture as to who should be paying for the damage caused by water erosion. By putting the responsibility on the municipality, the reasoning was that the municipality is responsible for city planning, for servicing land and streets. That they are, overall, in

control of the city and that they own the city hence owning all the land. Some stakeholders indicated that it is the municipality's responsibility rather than the private householders as the latter have already paid for erosion control as part of their monthly municipal bills.

The two groups represented by the private householders and the municipal group (public authority sector) and the interviewees expressed differing views on who should take responsibility. The pie graphs above show that the majority that chose the private householders to be the responsible group were the stakeholders from the public authority sector. On the other hand, the majority that chose the municipality were from the private householders sector. Interestingly, almost no developers indicated that the municipality is to be held responsible. Overall, this shows that there is disagreement between the groups with regards to payment for damages and the implementation of prevention measures.

These disagreements are also reflected on how to finance prevention measures (Figure 4). From the public authority sector, one interviewee stated that "the municipality only provides services; it does not have its own money. The residents provide the revenue, so they should be the ones paying." Another interviewee stated that "the damages are caused by natural causes and the municipality is not responsible for natural causes." While from the private householders one interviewee stated that the "municipality should service everything, it is under their control"; and another stated that "since people pay [for] services to the municipality, any damages that occur even within the individual yards, the municipality must attend to it."

Assessment of the Stakeholders' Understanding of Water Erosion Processes

The majority of the stakeholders know the process of water erosion in terms of the damages caused by erosion as only a few pointed out areas such as steep slopes as possibly the most affected (section 3.1). This section therefore analyses their understanding of the water erosion process.

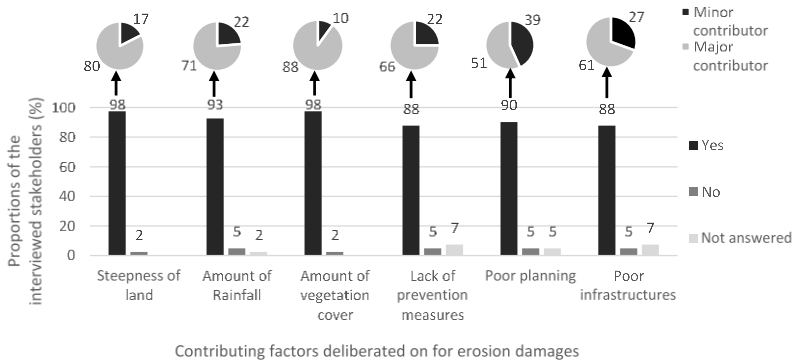

Figure 5: Understanding of water erosion in terms of contributing factors. The pie graphs illustrate the percentage (%) in relation to whether stakeholders considered the factors to be minor or major contributing factors

The stakeholders were asked to indicate whether factors including the steepness of the land, the amount of rainfall and of vegetation cover, the lack of prevention measures, poor planning and poor infrastructure contribute to erosion damages or not. These factors are the most critical factors influencing the process of water erosion (Bryan, 2000; Lal, 2001). The majority of the stakeholders agreed that these factors contribute to erosion damages (Figure 5). The respondents additionally specify further contributing factors; roads being gravel, too many squatter camps, houses built on hills and on water courses, places being underdeveloped; and lack of boundary walls to block the water. Clearly, these factors support those provided to them (Figure 5). The pie graphs show that the stakeholders generally understand that the highest contributing factors are the amount of vegetation and the steep slopes, while poor infrastructure and poor planning were considered slightly less. Overall, it shows that natural factors are understood to be major contributing factors to erosion damages in Windhoek than management-related factors.

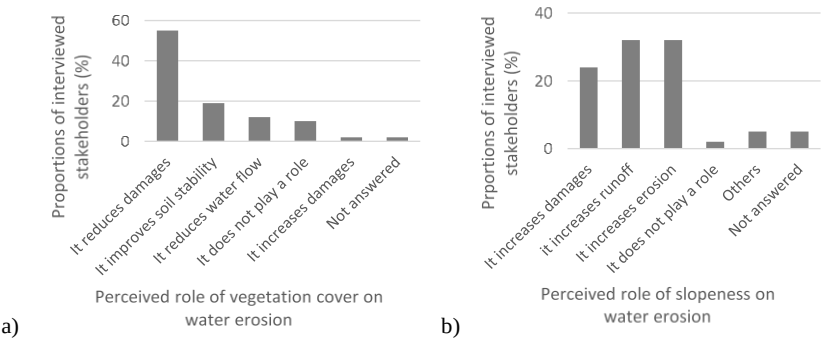

Figure 6: Perceived role of: a) vegetation cover, b) slope of the land on water erosion

Figure 6 above shows the perceptions of the stakeholders with regards to the role of vegetation cover and steep slopes on water erosion. For vegetation cover, the majority simply indicated that it reduces erosion damages resulting from erosion (Figure 6a). However, a smaller percentage appeared to have more detailed knowledge as they indicated that it improves soil stability while others referred to its ability to reduce water flow. In addition, three private householders and one councillor indicated that the amount of vegetation cover does not play any role in erosion whereas one developer indicated that the high amount of vegetation cover actually increases the damages. With regards to the slopes, the majority of the stakeholders indicated that a large slope increases erosion damages, runoff and erosion (Figure 6b). These results also show that there is a positive perception of the role of vegetation cover and slopes, with only a few stakeholders responding negatively. Vegetation is often removed to clear the land for construction. While in formal settlements vegetation cover is allowed to recover (Figure 7), in informal settlements it is mostly cleared off for general hygienic purposes and due to the heavy use of fire wood (Labbe et al., 2006).

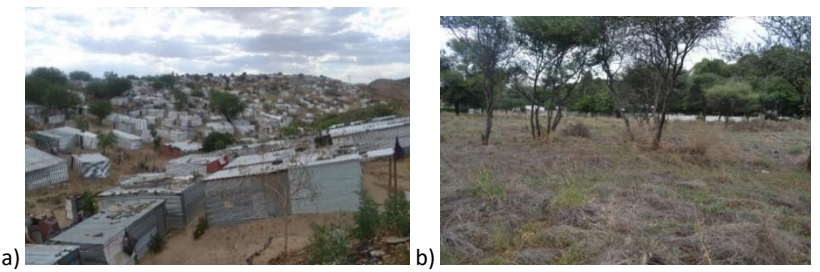

Figure 7: Typical vegetation cover in settlements: a) informal, b) formal

Discussion

In an attempt to understand the problem of urban water erosion in urban dryland communities, this research aimed at exploring how urban and local communities perceived water erosion, the contributing factors and related damages.

Awareness of Water Erosion

The study demonstrated that there is little awareness among stakeholders about water erosion as a phenomenon but the awareness is more in terms of the identified damages. This is demonstrated by the fact that the majority (55%) of the stakeholders pointed out that urbanised areas and low income areas are the most affected areas. This is further supported by their explanations which were mainly according to how infrastructure might have increased the damages in those areas. Only 36% of the stakeholders indicated that suburbs with higher levels of slopes or areas where water accumulates are affected the most; indicating their knowledge of the phenomenon. A recent study by Shikangalah et al. (2017) indicated that areas located on higher parts of hills such as Kleine Kuppe and Ludwigsdorf could potentially have been eroded more today if good land management practices were not in place (Figure 8). The map below (Figure 8) shows a spatial distribution of water erosion and this map was derived from a recent field survey data by the current researchers. The map corresponds with the majority's indication of the most affected area as those representing lower income locations. According to the stakeholders, the reasons why the most affected areas are in lower income locations include the fact that there is insufficient infrastructure, lack of services and the use of low quality building materials. The low quality building materials make structures unable to withstand the high lateral loads due to erosion, especially in the informal settlements of Windhoek where shacks are built from cheap and recycled materials (Labbe et al., 2006).

The stakeholders' awareness is mainly associated with damages as the researchers had predicted. Additionally, the study demonstrated that there is a notable disparity between stakeholders with regards to the level of perceptions about the seriousness of the damages: Whereas private householders considered the erosion damages as serious, the decision-makers regarded the same damage to be only moderate. The perceptions of the private householders might be influenced by their direct observation within the community. Likewise, the perceptions of the public authorities can be attributed to the fact that erosion falls outside their mandate as the city currently lacks a policy aimed at addressing the problem of water erosion.

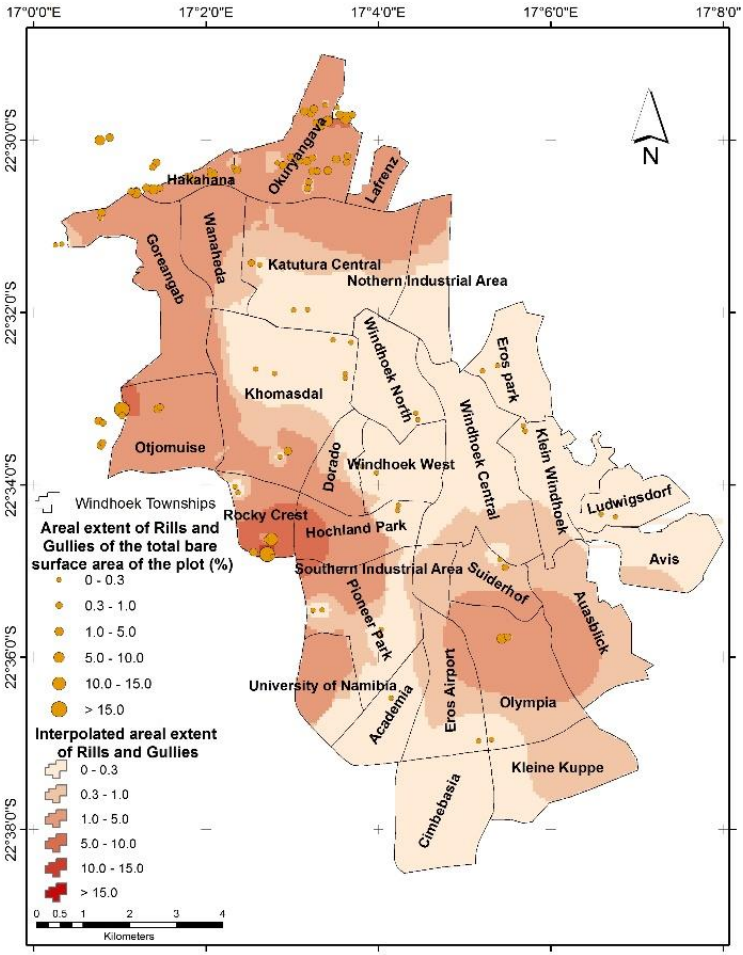

Figure 8: Spatial distribution of erosion in Windhoek

Understanding of Erosion's Underlying Mechanism Processes

Contrary to the researchers' expectations, the study demonstrated that there is a coherent understanding of factors contributing to water erosion and stakeholders are fairly cognisant of the role of vegetation cover and steep slopes in controlling water erosion. Vegetation cover is well documented as a parameter that reduces the risk of water erosion (Vrieling, de Jong, Sterk & Rodrigues, 2008; Wang et al., 2012; Zhongming, Lees, Feng, Wanning & Hajing, 2010; Zhou, Luukkanen, Tokola & Nieminen, 2008), with at least a minimum of 40% grass cover needed to reduce erosion in dryland cities (Gutierrez & Hernandez, 1996; Podwojewski, Janeau, Grellier,

Valentin, Lorentz & Chaplot, 2011; Shikangalah et al., 2017). The stakeholders' understanding corresponds with the views of these scholars.

The majority stated that more vegetation reduces erosion and it improves soil stability; while the steep slopes increase runoff, erosion and associated damages. However, even though the stakeholders understood the importance of vegetation cover, currently not many initiatives are directed towards improving vegetation cover in the most affected areas. Instead, vegetation cover is currently being cleared off on the stream banks by the local and central government in an attempt to reduce criminal activities such as robbery, and it is usually also cleared by many householders for hygienic purposes in their backyards. Although the data were not enough to properly establish this assumption, it appears that vegetation cover is however commonly grown in the back yards of the houses in the low density suburbs for aesthetic purposes and also as a symbol of status, to show that one can afford the cost of the irrigation water and the labour involved in maintaining it.

Responsibility for Water Erosion Prevention

Stakeholder participation is increasingly becoming fundamental for managing environmental resources (Stanghellini & Colletnine, 2008). Yet despite the fact that the city of Windhoek is highly affected by water erosion (Shikangalah et al., 2017), this study shows that the stakeholders are not willing to take responsibility to address the problem. The interviewed stakeholders recognised the public authorities (such as city managers) and private householders (such as property owners) as entities responsible for payments for and the implementation of prevention measures of erosion damages. However, each of these sectors shifted the responsibility to each other. This current attitude is likely to create a dilemma for the city especially for the informal settlements where land is normally occupied illegally and the settlements are not part of the plans or land management of the local public authorities. In order to successfully manage environmental problems locally, there is a need for the stakeholders to recognise the problem, the importance of their own individual roles and to collectively protect their local environment (Sennesa, Gombert-Courvoisier, Ribeyre & Felonneau, 2012; United Nations, 2011).

The question that might be asked therefore is, who should really be responsible for addressing the problem of water erosion in Windhoek? Many natural hazards (such as earthquakes, flooding and mudslides) in urban areas are the responsibility of the local governments (Cho, Gordon, Moore, Richardson, Shinozuka & Chang, 2001; Tas, Tas, Durak & Atanur, 2013; Uitto, 1998), including water erosion (Burby, 1995; Lizairraga-Arciniegat, Appendini-Albretchsen & Fitcher, 2001; Paterson, Luger, Burby, Kaiser, Malcom & Beard, 1993). However, in Windhoek it appears that the responsibility is clearer for the high income areas while in other suburbs the priorities of providing basic needs such as infrastructure like domestic water provision

precede the importance of addressing water erosion. In the informal settlements, addressing the problem of land tenure might be a higher priority for the local government compared to erosion.

Conclusion

This study demonstrates that there is a high level of awareness of the damages caused by urban water erosion (severe for household and moderate for public authority), but that urban water erosion itself is not considered a phenomenon which needs to be considered in an urban management context. In order to minimise the problem of water erosion, there is a need for the society to recognise the phenomenon, to clearly see the linkages between the damages and the phenomenon, and to set up appropriate management and prevention schemes. This is equally important for the developers and the politicians who are actively involved in city development. An increased awareness is also important for the people in the informal settlements where planning and management is lacking or not existent. Such an initiative will prove advantageous in terms of safeguarding their properties while also protecting the environment. Lastly, though water erosion might not be easy to change, the issue is very important considering the amount of the damage it causes. The study therefore recommends further studies aimed at analysing the economic impacts of damages and the possible prevention measures as well as the influence of other aspects such as the period of property ownership on the attitudes and perceptions of stakeholders towards water erosion.

Like any other study, this also has its limitations which should be taken into consideration in interpreting its results. It should be noted that in the section on understanding the process of water erosion, the researchers provided choices because they did not want to compel the stakeholders or to make them feel uncomfortable if direct questions about their knowledge were asked. However, it was felt that the outcome could have been slightly different if the researchers had not provided the choices. At the beginning of the interviews, some of the stakeholders had even asked the interviewer to explain what water erosion was and they appeared to realise the process only when the possible damages were mentioned. Furthermore, no further factor were provided by the stakeholders themselves even though they could specify additional factors. This can be further interrogated by other scholars.

References

Agle, B. R., & Mitchell, R. K. (1999). Who matters to CEOs? An investigation of stakeholder attributes and salience, corporate performance, and CEO values. *Academy of Management Journal*, *42*(5), 507–525.

Aksoy, H., & Kavvas, M. L. (2005). A review of hillslope and watershed scale erosion and sediment transport models. *Catena*, *64*(2–3), 247–271.

Amsalu, A., & de Graaff, J. (2006). Farmers' views of soil erosion problems and their conservation knowledge at Beressa watershed, central highlands of Ethiopia. *Agriculture and Human Values*, *23*(1), 99–108.

Ananda, J., & Herath G. (2003). Soil erosion in developing countries: A socio-economic appraisal. *Journal of Environmental Management*, *68*,343–353.

Anigbogu, N. A. (2001). The reciprocal relationship between construction and soil erosion. *Journal of Environmental Science*, *4*(2), 55–59.

Bong, C. H. J., Lau, T. L., & Ghani, A. A. (2011, December). *Sediment deposition characteristics of urban concrete drains in Kuching City, Sarawak, Malaysia*. Paper presented at the 3rd International Conference on Managing Rivers in the 21st Century: Sustainable Solutions for Global Crisis of Flooding, Pollution and Water Scarcity, Penang, Malaysia.

Bryan, R. B. (2000). Soil erodibility and processes of water erosion on hillslope. *Geomorphology*, *32*(3–4), 385–415.

Burby, R. J. (1995). Coercive versus cooperative pollution control: Comparative study of state programs to reduce erosion and sedimentation pollution in urban areas. *Environmental Management*, *19*(3), 359–370.

Cantón, Y., Solé-Benet, A., De Vente, J., Boix-Fayos, C., Calvo-Cases, A., Asensio, C., & Puigdefábregas, J. (2011). A review of runoff generation and soil erosion across scales in semiarid south-eastern Spain. *Journal of Arid Environments*, *75*(12), 1254–1261.

Cho, S., Gordon, P., Moore II, J. E., Richardson, H. W., Shinozuka, M., & Chang, S. (2001). Integrating transportation network and regional economic models to estimate the costs of a large urban earthquake. *Journal of Regional Science*, *41*(1), 39–65.

Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society*, *28*(1–2), 63–80.

Cordano, M., Frieze, I. H., & Ellis, K. M. (2004). Entangled affiliations and attitudes: An analysis of the influences on environmental policy stakeholders' behavioural intentions. *Journal of Business Ethics*, *49*(1), 27–40.

Cornelis, W. M. (2006). Hydroclimatology of wind erosion in arid and semiarid environments. In P. D'Odorico & A. Porporato (Eds.). *Dryland Ecohydrology* (pp 141-159). Amsterdam, Netherlands: Springer.

Duranton, G. (2015). Growing through cities in developing countries. *World Bank Research Observer*, *30*(1), 39–73.

Evans, R. (2002). An alternative way to assess water erosion of cultivated land - Field-based measurements: And analysis of some results. *Applied Geography*, *22*(2), 187–208.

Feng S., & Fu, Q. (2013). Expansion of global drylands under a warming climate. *Atmospheric Chemistry and Physics*. 13:10081–10094.

Frayne, B. (2007). Migration and the changing social economy of Windhoek, Namibia. *Development Southern Africa*, *24*(1), 91–108.

Fu, B.-J., Wang, Y.-F., Lu, Y.-H., He, C.-S., Chen, L.-D., & Song, C.-J. (2009). The effects of land-use combinations on soil erosion: A case study in the Loess Plateau of China. *Progress in Physical Geography*, 33(6), 793–804.

Gaffield, S. J., Goo, R. L., Richards, L. A., & Jackson, R. J. (2003). Public health effects of inadequately managed storm water runoff. *American Journal of Public Health*, *93*(9), 1527–1533.

Galletta, A. (2013). *Mastering the semi-structured interview and beyond: From research design to analysis and publication*. New York, NY: NYU Press.

García-Ruiz, J. M., Lana-Renault, N., Beguería, S., Lasanta, T., Regüés, D., Nadal-Romero, E., … Alatorre, L. C. (2010). From plot to regional scales: Interactions of slope and catchment hydrological and geomorphic processes in the Spanish Pyrenees. *Geomorphology*, *120*(3–4), 248–257.

Glasgow, L., Langaigne, B., Thomas, C., Harvey, O., & Campbell, E. A. (2018). Public knowledge and attitudes towards climate change and its impacts on ecosystems in Grenada. *American Journal of Climate Change*, *7*, 600-610.

Gray, M., Keating, J., Moody, J., Swan, D., & Keating, J. (2008). *Erosion control in Otjomuise, Namibia*. Retrieved fromhttps://web.wpi.edu/Pubs/E-project/Available/E-project-052108-082927/unrestricted/RWH_Final_paper_5-20-08.pdf

Greunen, S. (2013). Assessing the resilience of Windhoek on the road to re-defining sustainability. *20th General Assembly and Conference of the Commonwealth Association of Architects*, 1–12. Retrieved from http://www.comarchitect.org/assessing-the-resilience-of-windhoek-on-the-road-to-re-defining-sustainability/

Gutierrez, J., & Hernandez, I. I. (1996). Runoff and interrill erosion as affected by grass cover in a semi-arid rangeland of northern Mexico. *Journal of Arid Environments*, *34*(3), 287–295.

Haas, J., & Ban, Y. (2014). Urban growth and environmental impacts in Jing-Jin-Ji, the Yangtze, River Delta and the Pearl River Delta. *International Journal of Applied Earth Observation and Geoinformation*, *30*(1), 42–55.

Harris, J. A., & Adams, B. J. (2006). Probabilistic assessment of urban runoff erosion potential. *Canadian Journal of Civil Engineering*, *33*(3), 307–318.

Heckathorn, D. (2011). Snowball versus respondent driven sampling. *Sociological Methodology*, *4*(1), 355–366.

Heitz, C., Spaeter, S., Auzet, A. V., & Glatron, S. (2009). Local stakeholders' perception of muddy flood risk and implications for management approaches: A case study in Alsace (France). *Land Use Policy*, *26*(2), 443–451.

Huang, S. L., Yeh, C. T., & Chang, L. F. (2010). The transition to an urbanizing world and the demand for natural resources. *Current Opinion in Environmental Sustainability*, *2*(3), 136–143.

Izazola, H., Martínez, C., & Marquette, C. (1998). Environmental perceptions, social class and demographic change in Mexico City: A comparative approach. *Environment and Urbanization*, *10*(1), 107–118.

Karami, S., Shobeiri, S. M., Jafari, H., & Jafari, H. (2017). Assessment of knowledge, attitudes, and practices (KAP) towards climate change education (CCE) among lower secondary teachers in Tehran, Iran. *International Journal of Climate Change Strategies and Management*, *9*(03), 402-415.

Kötter, T., & Friesecke, F. (2007). Developing urban indicators for managing mega cities. *Land Governance in Support of the MDGs: Responding to New Challenges.* Retrieved from https://www.fig.net/resources/proceedings/2009/fig_wb_2009/papers/urb/urb_2_koetter.pdf

Labbe, N., Mcbride, N., & Ray, E. (2006). *Flooding and erosion control in the informal settlements of Windhoek, Namibia.* Retrieved from https://web.wpi.edu/Pubs/E-project/Available/E-project-050406-032633/unrestricted/FinalIQP.pdf

Lahnsteiner, J., & Lempert, G. (2007). Water management in Windhoek, Namibia. *Water Science and Technology*, *55*(1–2), 441–448.

Lal, R. (1998). Soil erosion impact on agronomic productivity and environment quality. *Critical Reviews in Plant Sciences*, *17*(4), 319–464.

Lal, R. (2001). Soil degradation by water erosion. *Land Degradation & Development*, 539, 519–539.

Lange, A., Siebert, R., & Barkmann, T. (2015). Sustainability in land management: An analysis of stakeholder perceptions in rural Northern Germany. *Sustainability*, *7*(1), 683–704.

Le Roux, J.J., Morgenthal, T., & Malherbe, J. (2008). Water erosion prediction at a national scale for South Africa. *Water SA* 34, 305–314.

Ligonja, P. J., & Shrestha, R. P. (2013). Soil erosion assessment in Kondoa eroded area in Tanzania Using Universal Soil Loss Equation, Geographic Information Systems and Socioeconomic Approach. *Land Degradation & Development*, *26*, 367–379.

Lizárraga-Arciniega, R., Appendini-Albretchsen, C., & Fitcher, D. (2001). Planning for beach erosion: A case study, Playas de Rosarito, B.C. Mexico. *Journal of Coastal Research*, *17*(3), 636–644.

Magnusson, E. & Marecek, J. (2015). *Doing interview-based qualitative research: A learner's guide*. Cambridge University Press.

Mapani, B. S., & Schreiber, U. (2008). Management of city aquifers from anthropogenic activities: Example of the Windhoek aquifer, Namibia. *Physics and Chemistry of the Earth*, *33*(8–13), 674–686.

McAdams, J. W., Rehr, R., Kobayashi, N., & DeArman, V. (2019). Measuring National Environmental Health Association member attitudes, awareness, and behaviors on climate change: Results from three consecutive annual surveys. *Journal of Environmental Health*, *81*(8), 40-43.

McLeman, R., & Smit, B. (2006). Migration as an adaptation to climate change. *Climatic Change*, 76(1-2), 31–53.

Merz, B., Kreibich, H., Schwarze, R., & Thieken, A. (2010). Assessment of economic flood damage. *Natural Hazards and Earth System Science*, *10*(8), 1697–1724.

Mitter, H., Kirchner, M., Schmid, E., & Schoenhart, M. (2014). The participation of agricultural stakeholders in assessing regional vulnerability of cropland to soil water erosion in Austria. *Regional Environmental Change*, *14*(1), 385–400.

Morgan, R.P.C. (1995). *Soil erosion and conservation*. (2nd ed.). London, England: Longman Group, Ltd.

Mutekanga, F., Kessler, A., Leber, K., & Visser, S. (2013). The use of stakeholder analysis in Integrated Watershed Management: Experiences from the Ngenge Watershed, Uganda. *Mountain Research and Development*, *33*(2), 122–131.

National Planning Commission. (2012). *Namibia 2011 Population and housing census Preliminary results*. Windhoek, Namibia: Author.

Nearing, M. A., Pruski, F. F., & O'Neal, M. R. (2004). Expected climate change impacts on soil erosion rates: A review. *Journal of Soil and Water Conservation*, *59*(1), 43–50.

Okoba, B. O., & de Graaff, J. (2005). Farmers' knowledge and perceptions of soil erosion and conservation measures in the Central Highlands, Kenya. *Land Degradation and Development*, *16*(5), 475–487.

Paterson, R. G., Luger, M. I., Burby, R. J., Kaiser, E. J., Malcom, H. R., & Beard, A. C. (1993). Costs and benefits of urban erosion and sediment control: The North Carolina experience. *Environmental Management*, *17*(2), 167–178.

Pendleton, W., Crush, J., & Nickanor, N. (2014). Migrant Windhoek: Rural-urban migration and food security in Namibia. *Urban Forum*, *25*, 191-205.

Pickett, S. T., Cadenasso, M. L., Grove, J. M., Nilon, C. H., Pouyat, R. V., Zipperer, W. C., & Costanza, R. (2001). Urban ecological systems: Linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. Annual review of ecology and systematics, *32*(1), 127-157.

Pimentel, D. (2006). Soil erosion: A food and environmental threat. *Environment, Development and Sustainability*, *8*(1), 119–137.

Pimentel, D., & Kounang, N. (1998). Ecology of soil erosion in ecosystems. *Ecosystems*, *1*(5), 416–426.

Podwojewski, P., Janeau, J. L., Grellier, S., Valentin, C., Lorentz, S., & Chaplot, V. (2011). Influence of grass soil cover on water runoff and soil detachment under rainfall simulation in a sub-humid South African degraded rangeland. *Earth Surface Processes and Landforms*, *36*(7), 911–922.

Portnov, B. A., & Paz, S. A. (2008). Climate change and urbanization in Arid Regions. *Annals of Arid Zone*, 47(3 & 4), 1–15.

Prasannakumar, V., Vijith, H., Abinod, S., & Geetha, N. (2012). Estimation of soil erosion risk within a small mountainous sub-watershed in Kerala, India, using Revised Universal Soil Loss Equation (RUSLE) and geo-information technology. *Geoscience Frontiers*, *3*(2), 209–215.

Prell, C., Hubacek, K., & Reed, M. (2009). Stakeholder analysis and social network analysis in natural resource management. *Society & Natural Resources*, *22*(6), 501–518.

Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. *Biological Conservation*, *141*(10), 2417–2431.

Reidsma, P., Ewert, F., Lansink, A. O., & Leemans, R. (2010). Adaptation to climate change and climate variability in European agriculture: The importance of farm level responses. *European Journal of Agronomy*, *32*(1), 91–102.

Reynolds, J.F., Smith, D.M.S., Lambin, E.F., Turner, B.L., Mortimore, M., Batterbury, S.P.J., … & Herrick, J.E, (2007). Global desertification: Building a site for dryland development. *Science*. 316:847–851.

Sennes, V., Gombert-Courvoisier, S., Ribeyre, F., & Felonneau, M-L. (2012). Citizens' environmental awareness and responsibility at local level. *International Journal of Urban Sustainable Development*, *4*(2), 186–197.

Shikangalah, R., Jeltsch, F., Blaum, N., & Mueller, E. (2016). A review on urban soil water erosion. *Journal for Studies in Humanities and Social Sciences*, *5*(1), 163–178.

Shikangalah, R., Paton, E., Jeltsch, F., & Blaum, N. (2017). Quantification of areal extent of soil erosion in dryland urban areas: An example from Windhoek, Namibia. *Cities and the Environment (CATE)*,*10*(1), 1–21

Shuster, W. D., Bonta, J., Thurston, H., Warnemuende, E., & Smith, D. R. (2005). Impacts of impervious surface on watershed hydrology: A review. *Urban Water Journal*, 2(4), 263–275.

Stanghellini, P. S., & Collentine, D. (2008). Stakeholder discourse and water management - implementation of the participatory model CATCH in a Northern Italian alpine sub-catchment. *Hydrology and Earth System Sciences*, *12*(1), 317–331.

Strahle, A.H. (2010). *Introducing physical geography*. (5th ed.). Chichester, United Kingdom: John Wiley && Sons

Sutherland, R. A., & Tolosa, C. A. (2000). Multi-element analysis of road-deposited sediment in an urban drainage basin, Honolulu, Hawaii. *Environmental Pollution*, *110*(3), 483–495.

Tas, M., Tas, N., Durak, S., & Atanur, G. (2013). Flood disaster vulnerability in informal settlements in Bursa, Turkey. *Environment and Urbanization*, *25*(2), 443–463.

Tooth, S. (2000). Process, form and change in dryland rivers: A review of recent research. *Earth Science Reviews*, 51(1-4), 67–107.

Uitto, J. I. (1998). The geography of disaster vulnerability in megacities: A theoretical framework. *Applied Geography*, *18*(1), 7–16.

UN - Habitat. (2015). *Habitat III Issue Papers 22 – Informal settlements*. *United Nations Conference on Housing and Sustainable Urban Development* (Vol. 22). New York, NY: Author.

United Nations. (2011). *Paving the way for sustainable consumption and production: The Marrakech Process progress report. United Nations Environment Programme* (UNEP). Retrieved from http://www.unep.fr/scp/marrakech/pdf/Marrakech Process Progress Report FINAL.pdf

United Nations. (2012). *World urbanization prospects: The 2011 revision*. Retrieved from https://www.un.org/en/development/desa/population/publications/pdf/urbanization/WUP2011_Report.pdf

Varvasovszky, Z., & Brugha, R. (2000). How to do (or not to do) ... A stakeholder analysis. *Health Policy and Planning*, *15*(3), 338–345.

Vásquez-Méndez, R., Ventura-Ramos, E., & Domínguez-Cortázar, M. A. (2011). Soil erosion processes in semi-arid areas: The importance of native vegetation. *INTECH Open Access Publisher*, *1*, 25–41.

Verón, S., Paruelo, J.M., & Oesterheld, M. (2006). Assessing desertification. *Journal of Arid Environment.* 66,751–763.

Vrieling, A. (2006). Satellite remote sensing for water erosion assessment: A review. *Catena*, *65*(1), 2–18.

Vrieling, A., de Jong, S. M., Sterk, G., & Rodrigues, S. C. (2008). Timing of erosion and satellite data: A multi-resolution approach to soil erosion risk mapping. *International Journal of Applied Earth Observation and Geoinformation*, *10*(3), 267–281.

Wakhungu, J., Huggins, C., Nyukuri, E., & Lumumba, J. (2010). *Approaches to informal settlements in Africa: Experiences from Kigali and Nairobi.* Retrieved from https://www.academia.edu/5052103/

Wang, G., Innes, J., Yusheng, Y., Shanmu, C., Krzyzanowski, J., Jingsheng, X., & Wenlian, L. (2012). Extent of soil erosion and surface runoff associated with large-scale infrastructure development in Fujian Province, China. *Catena*, *89*(1), 22–30.

Wei, W., Chen, L., Yang, L., Fu, B., & Sun, R. (2012). Spatial scale effects of water erosion dynamics: Complexities, variabilities, and uncertainties. *Chinese Geographical Science*, *22*(2), 127-143.

Yair, A., and Raz-Yassif, N. (2004). Hydrological processes in a small arid catchment: Scale effects of rainfall and slope length. *Geomorphology*, *61*(1-2), 155–169.

Zegeye, A. D., Steenhuis, T. S., Blake, R. W., Kidnau, S., Collick, A. S., & Dadgari, F. (2010). Assessment of soil erosion processes and farmer perception of land conservation in Debre Mewi watershed near Lake Tana, Ethiopia. *Ecohydrology and Hydrobiology*, *10*(2–4), 297–306.

Zhongming, W., Lees, B. G., Feng, J., Wanning, L., & Haijing, S. (2010). Stratified vegetation cover index: A new way to assess vegetation impact on soil erosion. *Catena*, *83*(1), 87–93.

Zhou, P., Luukkanen, O., Tokola, T., & Nieminen, J. (2008). Effect of vegetation cover on soil erosion in a mountainous watershed. *Catena*, *75*(3), 319–325.