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Wetlands Encroachment and the Spatial Resilience of Ecosystems in Peri-Urban Areas: the Case of Budeli, Mutoti and Mphego in Nandoni, Limpopo Province, South Africa

Priscila Chioneso Banda, Trynos Gumbo, Emmaculate Ingwani

(Priscila Chioneso Banda, PhD Candidate Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg, priscbanda@gmail.com)
(Trynos Gumbo, Associate Professor and Head; Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg; tgumbo@uj.ac.za)
(Emmaculate Ingwani, Senior Lecturer; Department of Urban and Regional Planning, Faculty of Science, Engineering and Agriculture, University of Venda, ingwani@gmail.com)

1 ABSTRACT

The study examines the effects of encroachment on wetlands in peri-urban areas on the spatial resilience of peri-urban areas‘ ecosystems. This is against the background that there are continued encroachments on wetlands in peri-urban areas that are resulting in reduced size and quality of wetlands.The consequential effects include disappearance of wetlands creating an imbalance in nature that compromises the resilience of the peri-urban ecosyttems. Informed by the social-ecological systems theoretical framework, the study adopts the post-positivists philosophy and the mixed methods research approach to guide the collection of data. Key informant interviews with purposively selected spatial planners, enviromentalists and traditional leaders were used to collect data. Mapping to establish the extent of how wetlands have been affected by development was also employed. Findings reveal that various activities have affected wetlands in the respective villages severely and these include brickmaking, coversion of wetlands into farmlands and expanding residential development onto wetlands areas.These activities have led to water pollution, erosion of wetland escarpments, natural vegetation loss, reduction in wetland inhabitant species and alteration of wetland sites. Wetland designated sites have dimisinshed showing the impact of these human activities. It is recommended that sustainable practices be adopted that sustain both the community and the enviroment to reduce the impacts of wetland encroachment by human activities coupled with strong partneships by community, local leaders and local authority. Recommndations are that concerned stakeholders should work together and form strong partnerships, an intergrated or inclusive approach in land allocation issues between the local authority and the traditional leaders be adopted and practiced, incorporation of community participatory initiatives that raise awareness on wetlands importance and the extent of how human activities compromise wetland habitat quality such as Imbizo and Mayor Mahosi Forum, continual enforcement by the local authority and local community engagement on the best practices that help sustain the enviroment at the same time that meet their livelihoods.

Keywords: Peri-urban areas, Ecosystems, Spatial resilience, Encroachment, Wetlands

2 INTRODUCTION

Wetlands encroachment discourse and its effects on peri-urban fringes ecosystems characterized by extreme development has gained impetus among researchers during the last decade and needs immediate attention as its neglect may consequently lead to wetlands drying up completely leading to increase in global warming (Newton et al., 2020). McHale et al. (2013) affirms that urbanization processes in the developing world shows that projections of urbanization in Africa grossly overestimate rural to urban migration and therefore confound the true definition of urbanization. Studies have shown that permanent urban migration is decreasing; not increasing in Africa (Ferguson, 2007 & Potts, 2009) and growth in established cities is a function of higher than normal birth rates in urban areas. Angel et al (2011) projection of a 12 fold increase in urban area in sub-Saharian Africa, show that the increase in urban land area will actually be due to the reclassification of rural areas as urban areas resulting from an ever-increasing rural population. Literally, rural is the new urban. Not only is the urban or rural dichotomy inadequate for addressing the needs of the growing populations in Africa, but the rural migration occurring on the continent is overwhelmingly toward smaller cities and towns (Simon et al. 2004; Collinson et al. 2007). Peri-urban areas that is, the landscape interface between the city and rural areas is no exception to population boom dynamics exacerbated by livelihood deficient copying mechanisms (International Management Water Institute, 2018). They are considered as the transition area where activities have links with the city and exchange of products that takes place. Due to this, they are facing increasing demand of land to accommodate various development activities whose short term and long term produces detrimental effects to the surrounding ecosystem. Therefore, the

paper focuses on wetland encroachment and spatial resilience of ecosystems in peri urban areas, the case of Budeli, Mutoti and Mphego in Nandoni, Limpopo Province in South Africa. The paper starts by giving a brief introduction followed by conceptual synopsis, theoretical framework, materials and methods, results presentations and discussion and ends with the conclusion and recommendations.

3 CONCEPTUAL SYNOPSIS

Despite providing vital services, wetlands are declining at alarming rates faster than any other ecosystems (Millennium Ecosystem Assessment, 2005). Half of the world's wetlands have been lost since the beginning of the twentieth century (Davidson, 2014) and more than 60% of the remaining wetland ecosystems were being degraded or used unsustainably. As cities are increasingly challenged by rapid urbanization, population growth and the impacts of land degradation and climate change, they need to find adequate solutions for sustainable city development. As most of this development takes place in the riverside and coastal areas, the rapid loss of valuable wetland ecosystems makes our cities increasingly vulnerable to extreme weather events and climate change (Wetland International, 2019).

Wetland ecosystems are critical in making cities and towns livable through ecosystems services benefits to the people. These include provisioning services such as food, water; regulating services such as flood and disease control; cultural services such as spiritual, recreational and aesthetic benefits; and supporting services such as nutrient cycling, critical in, for example agricultural production. The vast range of ecosystem services provided by wetlands also includes the provision of water security to millions of people in rapidly growing towns and cities. Wetlands provide an essential role to the environment and natural resources through ecological, economical, socio-cultural, scientific and recreational services to the nation. Warning signals from recent international environmental reports are prompting countries and non-governmental organizations around the globe to search for ways to reorganize human activities, mitigate their ecological impacts, and reduce subsequent harmful consequences for human well-being. These developments, including both climate change and biodiversity loss, are linked to the deterioration of wetlands. African wetlands include, arguably, some of the most biologically productive systems on earth. In some instances rural economies are entirely dependent on the flow of ecosystem services that provide food, water, energy, building material, medicine, seasonal grazing and transportation. In addition, some of these wetlands are the mainstay of lucrative tourism industries that generate numerous jobs. Relative to more developed regions Africa has a high proportion of wetlands that might be considered in fairly good ecological condition. However, impacts on many are significant and pressure is increasing.

The study also focuses on the concept of ecological resilience that presumes the existence of multiple stability domains and the tolerance of the system to perturbations that facilitate transitions among stable states. Ecological resilience is defined by the magnitude of disturbance that a system can absorb before it changes stable states. Nandoni's peri-urban villages in Limpopo such as Budeli, Mutoti and Mphego have been facing similar challenges that are rapidly expanding economy and booming population, the choice between conservation of wetlands for future generations and landuse development for various uses such as residential, industrial and commercial become a difficult one. Wetland quality in the area is undergoing serious alteration or disturbance through encroachment. This is in many forms from specific village to village depending on its economic, social, environmental and political set up. The northern bank of Nandoni dam with villages Budeli, Mutoti and Mphego have the most dense vegetation and rich in species diversity. Wetland in these villages consists of riverine bushes that are being affected by overdrawing of water from them for different uses coupled with cultivation among other activities. The study sought to examine the effects of encroachment on wetlands on peri-urban areas (villages) on the spatial resilience of peri–urban areas ecosystems. These effects affect the size, character, habitat quality of these wetlands which consequently have a bearing on the spatial resilience of the surrounding ecosystems of the selected peri urban villages. National or local area policy on conservation of these wetlands in the area of Nandoni will also be investigated so as to see the missing piece of what exists in policy versus the status quo which is a continual violation through encroachment of development in these sensitive areas despite what policy has stipulated and enforced.

4 THEORETICAL FRAMEWORK

The study made use of the social-ecological systems theory. The overall drive for its adoption will make research findings more meaningful, acceptable to the theoretical constructs. The Social-Ecological Systems theory (SES) model provides a holistic perspective for examining wetlands ecosystems, the nature of their importance and what actions people can or should take in the interest of protecting the ecosystem services people enjoy from healthy, functioning wetlands wherever they are located. The theory recognises the many interrelationships and interdependencies between wetland ecosystems and people and calls for a balanced and pragmatic approach to halting and reversing the widespread loss and degradation of wetlands. It acknowledges the need to directly address tradeoffs between wetland conservation and human development needs, while ensuring ecological integrity. The SES perspective highlights the interdependencies of the coupled human and natural systems.

Change in both social and ecological systems is influenced by mitigating or amplifying feedbacks within and between these systems. Change is often uneven, with periods of relative stability pointed out by sudden change and shifts past tipping points, beyond which recovery to the earlier state is unlikely in the near term (Liu et al. 2007). The description of "human and natural systems" as coupled is an analytical distinction; humans are an indivisible part of the natural system. Human survival is utterly dependent on the benefits provided by ecosystems. Those ecosystem services are important because they provide food, water, shelter and other resources that constitute our life support system. Human activities involved in utilising these benefits have both deliberate and unintentional impacts on those very services. Ecosystems are steered by physical and biological processes; human activities are steered by individual and collective choices, although within natural constraints. On a societal level, these choices are in the form of public policy or governance structures that affect the resilience of social ecological systems. A key contributor to better ecosystem management is to develop effective governance structures that are aligned to both social and ecological factors of importance and explicit evaluation of what constitutes effective governance structures is required (Cumming et al. 2006; Guerrero et al. 2015). The challenge of reversing this rapid degradation of ecosystems while meeting increasing demands for ecosystem services will involve significant changes in policies, institutions and practices. Adaptive capacity and reorganisation play a pivotal role in the Social Ecological Systems theory as it represents the degree to which the ecosystem adapts to a disturbance in the form of human activities and reorganises or realigns itself to a stable condition or state.

In light of the study of wetland encroachment in Nandoni peri-urban villages and spatial resilience of surrounding ecosystems, the Social Ecological Systems theory is relevant in that the case study concerned involves human activities on wetlands ecosystems in peri urban villages that are causing an imbalance in the form of negative effects. Governance in the form of policy is challenged that is resulting in the gap that exists between wetland conservation policy enforcement measures versus the status quo that is a direct violation. The study involves a contestation of policy and human practices on the planning field and consequently striking a balance between ecosystem conservation and meeting the demand for ecosystem services by the local residents in Nandoni that allows the ecosystems to quickly bounce back and realigning itself.

5 STUDY AREA

The study focuses on Limpopo province South Africa, specifically Nandoni area along the Luvuvhu River. The study area is Nandoni dam (22◦5604500 S and 30◦2000700 E), whose construction was from 1998 to 2005. Nandoni dam falls under Ward 18 and 19 of Collins Chabane Local Municipality and Wards 19, 20, 26, 36, and 41 of Thulamela Local Municipality in the Vhembe District Municipality in Limpopo Province of South Africa (Figure 1).

Thulamela municipality area covers vast track of lands mainly tribal and Thohoyandou as its political, administrative and commercial centre. In terms of population it is the second largest of all the municipalities in Limpopo Province. The political leadership of the municipality is vested in the Municipal Council comprising of 81 Councillors of whom 41 are Ward or directly elected Councillors, 40 Proportional Representative (PR), representing political parties. Additional members of Council are 7 Senior Traditional Leaders or their representatives who sit on the Council as Ex-Officio representing the traditional systems of governance.

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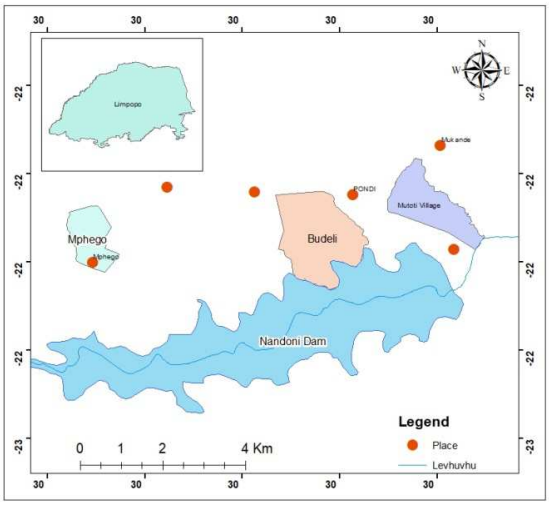

Figure 1: Map showing Nandoni Dam, Budeli, Mutoti and Mphego villages

The Nandoni Dam in terms of construction was premised by the desire of authorities to upgrade water resource management. This was paired with the wish to improve economic development through water-based recreation and tourism, a resource that had not yet been exploited in the region (Department of Water Affairs and Forestry, 2003). In other words, expectations were built amongst local communities that economic development would result from recreational utilization of the dam. It was anticipated that water-related recreation and ecotourism development in the study area would not only create employment for local communities but also improve their lives and livelihoods. In addition, the dam was also expected to act as a catalyst for new developments and initiatives in the area in poverty alleviation.

6 RESEARCH METHODOLOGY

6.1 Research design

The research paper employed the case study phenomelogical design which captures experiences of residents residing in three peri-urban villages namely, Budeli, Mutoti and Mphego in terms of engagement of wetland encroachment activities that are resulting in adverse effects. Experiences are wetland use over three spatially configured peri-urban villages.

6.2 Research approach

The paper adopted the mixed methods research approach where qualitative and quantitative are integrated to provide a more complete understanding of a research problem (Cresswell, 2018). Mixed methods research design infuses qualitative data that tend to be open-ended without predetermined responses and quantitative data that includes closed-ended responses. Mixed methods was ideal for the study on wetland encroachment and the spatial resilience of ecosystems in peri-urban areas in Nandoni, Limpopo like Budeli, Mutoti and Mphego as it integrates the qualitative and quantitative data into one database that aids in checking the validity of each database over the other. Qualitative and quantitative data identified as databases could help complement each other for example through the coupling of explanatory aspect with exploration aspect concerning the given objective, well suit research instruments in line with the given sample or population, the building of one database on other databases or alternate one database with another database back and forth during a research study.

6.3 Sampling design

The study made use of non-probability sampling that is purposive sampling to select the key informants such as spatial planners, environmentalists and chiefs using the researcher's judgment to determine the sample. Purposive sampling was used in the selection of key informants and wetland sites. The study considered eight (8) key informants consisting of four spatial planners from the Department of spatial planning, one environmentalist from the Department of Environment at Thulamela municipality and three traditional leaders from Budeli, Mutoti and Mphego villages.

6.4 Data collection instruments

The study both used primary data and secondary data sources that is, key informant interviews for spatial planners, environmentalists and traditional leaders and mapping through QGIS through Landsat satellite images. The type of data to be collected will be on wetland type, quality, size, characteristics, spatial configuration, degree of encroachment and resilience of surrounding ecosystem. Secondary data will also be used to gather data that is, documentation, archival records and internet sources.

6.5 Data analysis

The responses from key informant interviews were analysed using themes. The thematic analysis focused on nature of encroachment activities in the peri-urban villages of Nandoni, causes of wetland encroachment, effects of activities conducted on wetlands by local community villagers, extent of encroachment, policy strategies that can be employed so as to mitigate the effects of wetlands encroachment and implications on spatial resilience on ecosystems in peri-urban areas. Mapping was used in data collection as a compliment to key informant interviews ensuring data reliability and validity. Changes were mapped from 1996 after the new constitution for successive 10 year periods that is from 1996, 2006 and 2016 to 2022 to show the extent of change of wetland encroachment by development activities occurring in these peri-urban villages in Nandoni, Limpopo.

7 RESULTS PRESENTATIONS AND DISCUSSION

This section presents findings on nature of encroachment activities in the peri-urban villages of Nandoni, causes of wetland encroachment, effects of activities conducted on wetlands by local community, nature and extent of encroachment, policy strategies that can be employed so as to mitigate the effects of wetland encroachment and implications on spatial resilience on ecosystems in peri-urban areas. The research used Google earth engine (GEE) in classification and interpretation of images and key informant interviews to complement each other in data collection. GEE is a cloud based system which is capable of handling large petabytes of spatial data varying from vector to raster datasets (Noi Phan et al., 2020). GEE was preferred for classification than any other softwares because of its ability to do the whole process of image analysis and classification in cloud and then allows downloading of the images at last stage for map layout creation (Noi Phan et al., 2020). This means with GEE, you save a lot of space than rather download satellite images from earth explorer and then begin to preprocess them. Hence GEE is faster and efficient. Moreso, GEE provides level 2 and Top of the Atmosphere reflectance images, these are images which would have already gone through the process of preprocessing stages and are ready for use (Teluguntla et al., 2018). In this study Landsat satellite images with the inclusive of landsat 5 and 8 to cater for different years was used. Within the GEE environment, machine learning algorithm was chosen in a line of code and was applied to all the images for classification. In this case smileRandomForest algorithm was used due to its robustness compared to other classifiers. This algorithm then predicted or model the whole image based on the training samples provided. Classified images were exported to google drive where they were downloaded for use in ArcGIS for map layout creation.

7.1 Nature and extent of encroachment activities in the peri-urban villages of Nandoni

1. Recreational

Data collected from key informant interview responses and mapping revealed that there are recreational activities taking place on wetlands in Budeli and Mutoti villages. It was further reported that some of the wetlands consisting of recreational activities are privately owned by influential businessmen in Thohoyandou. Wetlands sites in these villages attract tourists as well as recreational events such as Flower garden festivals, wedding and corporate events that are inspired by the wetlands surrounding nature in the form of vegetation and inhabitant species.

2. Fishing

Key findings divulged that the community villagers' in Budeli and Mutoti engage in fishing activities from wetlands. They rely on acquatic life such as fish as a source of food. This is being practiced on wetland banks.

3 Retrieval of medicinal plants

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Findings reveal that in Mutoti wetland vegetation is mainly used as a source of medicinal plants by traditional herbalists as well as the local community villagers. The collection of wetland medicinal plants is used in conjuction with worship activities around the wetland area. This reveals that wetlands in this case are providing a joint function of provisioning and cultural ecosystem services.

4. Grazing of wetland pastures

Findings revealed that in Budeli there is overgrazing of wetland pastures by local community livestock such as cattle. This was sighted as leading to the deterioration of wetland vegetation quality and it is being practiced intensively.

5. Residential development

Data collected from key informants' responses and mapping revealed that Budeli, Mutoti and Mphego community have benefited through residential development that has encroached wetland sites. In Budeli some of the residential development has seen encroachment beyond the floodline. The residential development encroachments are deemed illegal by the local authority and the Traditional leaders are responsible of land allocation as far as rural or peri urban land is concerned. Through landuse landcover changes of the three per urban villages it can be seen that residential encroachment in the form of built up area has increased from 1996 up to 2022.

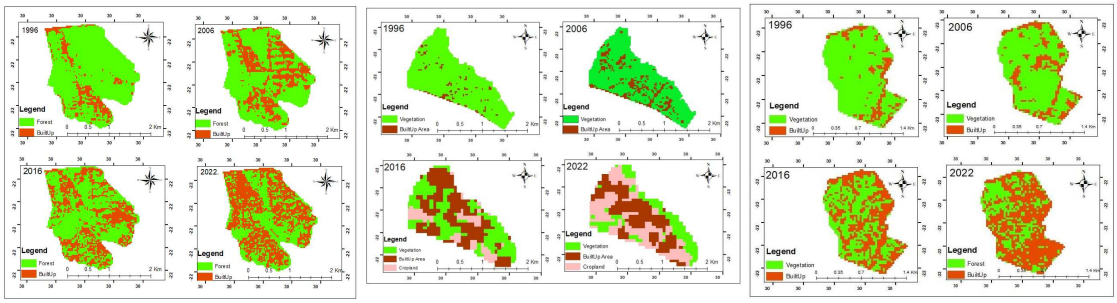

Figure 2: Landuse landcover changes for Budeli, Mutoti and Mphego in relation to residential development encroachment

Figure 2 shows land use land cover change maps for Budeli, Mutoti and Mphego and Table 1, Table 2 and Table 3 shows Land use land cover changes for Budeli, Mutoti and Mphego villages from 1996, 2006, 2016 and 2022.

1996			2006		
Class	Area	Percentage	Class	Area	Percentage
Forest	289	86.0119	Forest	230	68.4524
Built up	47	13.9881	Built up	106	31.5476
	336	100		336	100
2016			2022		
Class	Area	Percentage	Class	Area	Percentage
Forest	148	44.0476	Forest	129	38.3929
Built up	188	55.9524	Built up	207	61.6071
	336	100		336	100

Table 1: Landuse landcover changes for Budeli village from 1996, 2006, 2016 and 2022

1996			2006		
Class	Area	Percentage	Class	Area	Percentage
Forest	193	4.4554	Forest	170	15.8416
Built up	9	95.5446	Built up	32	84.1584
	202	100		202	100
2016			2022		
Class	Area	Percentage	Class	Area	Percentage
Forest	67	33.1683	Forest	60	29.7030
Built up	38	18.8119	Built up	100	49.5050
Crop	97	48.0198	Crop	42	20.7921
	202	100		202	100

Table 2: Landuse landcover changes for Mutoti village from 1996, 2006, 2016 and 2022

Table 1 illustrates how the land use and land cover changes have changed throughout successive 10 year periods from 1996 as the base year in Budeli village. Initially from 1996, forest land use gradually decreased from 1996, 2006, 2016 up to 2022. This gradual decrease is evidenced by the total area percentage from 86.0119%, 68.4524%, 44.0476% and 38.3929% respectively. In contrast to built up area which has

experienced a sharp increase from 13.9881%, 31.5478%, 55.9524% and 61.6071% respectively. This is evidence that forest area has been surpassed by development in the form of built up area. This is clear evidence that in Budeli, residential development is increasing at the expense of the natural vegetation ecosystem. If this remains unchecked may lead to disappearance of wetlands.

1996			2006		
Class	Area	Percentage	Class	Area	Percentage
Forest	108	85.71429	Forest	97	76.98413
Built up	18	14.28571	Built up	29	23.01587
	126	100		126	100
2016			2022		
Class	Area	Percentage	Class	Area	Percentage
Forest	65	51.5873	Forest	59	46.8254
Built up	61	48.4127	Built up	67	53.1746
	126	100		126	100

Table 3: Landuse landcover changes for Mphego village from 1996, 2006, 2016 and 2022

For Mutoti, illustration in Table 2 shows that built up area remained higher than forest area from 1996, 2006 and 2022 at 95.5446%, 84.1584% and 49.5050% respectively. In 2016 a new landuse area component emerged (crop) and coupled with the built up area in terms of percentage it was higher than forest area from 2016 up 2022 by a cumulative total of 66.8317% and 70.2971%. For Mphego, illustration in Table 3 showed forest landuse area having a sustained decrease from 1996, 2006, 2016 up to 2022 from 85.71429%, 76.98413% and 51.5873% up to 46.8254% for the respective years. In contrast there is a steady increase of Built up area from 1996, 2006, 2016 and 2022 from 14.28571%, 23.01587%, 48.4127% and 53.1746% respectively. The findings from the 3 villages reveal that there has been an increase in human activities with specific reference to residential development that has resulted in the alteration of the existing landscape to a new one that suits the population needs.

6. Brick molding

Findings revealed that Mphego village is witnessing a unique activity of brick-making that is benefiting that local community at the same time that is resulting in wetland encroachment within that area. Key informants highlighted that brick-making is regarded a mining activity hence deemed illegal by Thulamela local municipality. Brick making is conducted and it involves digging up of soil that is used to manufacture bricks. Water in wetland used also in brick molding.

7. Farming

Data collected from findings disclosed that in Mutoti farming activities in addition to residential development has also been an activity that is leading to wetland encroachment. This process has seen the conversion of wetland area or pastures being cleared for farming of different crops that the villagers rely on as food. The emergence of crop land can be seen in Figure 3 Landuse landcover change maps from 2016 up to 2022.This shows human intervention to the natural environment.

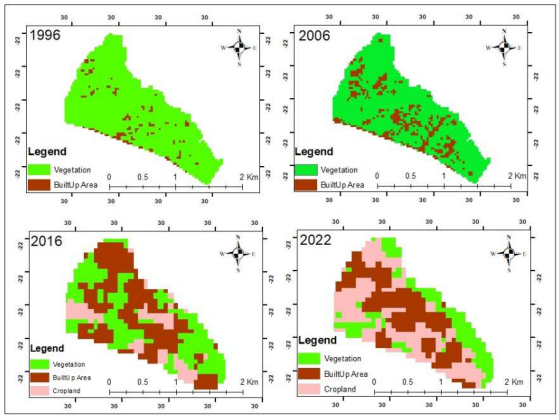

Figure 3: Landuse landcover changes for Mutoti village for 1996, 2006, 2016 and 2022.

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7.2 Causes of wetland encroachment

1. Poverty

Findings reveal that poverty is resulting in wetland encroachment as villagers are engaging in activities close to wetlands to augment their livelihood. Data collected through interviews with key informants indicate that the majority of people that reside in Budeli. Mutoti and Mphego are unemployed and have no decent sources of income, a situation that makes them poor. To earn a living, the residents turn to the environment for livelihood activities as an adaptive measure that include brick making, carpet weaving and farming. These activities sustain them but have serious effects to the environment. These activities are carried out on wetlands because of the availability of the natural resources found on wetlands such as water, soil and reed vegetation

2. Population expansion–new household formation

Findings from data collected from key sources of the study disclosed that population expansion which has led to new household formation is also a contributing factor on the cause of wetland encroachment. Historical background on the relocation of the affected households when Nandoni dam was built from 1998 to 2005 resulted in people being settled in the villages close to Nandoni dam as a proactive response. In the Nandoni land compensation case, there was no land readily available that would offer as alternative land and post the land resettlement and compensation population has increased in the peri-urban villages namely Budeli, Mutoti and Mphego. As a resulted it has created inequalities that have affected the quality of life of the locals and as a copying mechanism (wetland encroachment) to take advantage of the natural resources found within them. This comes from the background that wetlands are naturally existing, free, not owned by anyone and anyone within the village can access them for their own benefit without facing any confrontation.

3. Poor planning

Poor planning in terms of land resettlement when the Nandoni dam was built was also a finding on the cause of wetland encroachment. Key informant data collected from interviews noted that people were not supposed to be resettled close to Nandoni dam in the first place as this place is characterized by wetlands. There was need for a proper resettlement plan that would leave the area near Nandoni dam characterized by wetlands left in its natural state without any development. They also noted that because of the shortsightedness of the planning and resettlement, post the land resettlement and compensation population has increased in villages such as Budeli, Mutoti and Mphego hence it has created inequalities that have an effect in the quality of life of the locals hence as copying mechanisms wetland encroachment to take advantage of the natural resources found within them as the only way out.

4. Weak enforcement coupled with greed

Findings also revealed that weak enforcement by the local authority is also a cause of continued wetland encroachment. Data collected from key informants showed that the issue of land ownership coupled with land tenure systems that facilitates easy and cheap land transactions has increased the level of wetland encroachment in the selected villages. Traditional leaders have the mandate when it comes to rural land allocation hence the local authority have no say and hence come in to manage on what has been deliberated and end up the enemies. In the case of Mphego that involves brick-making which is a mining activity by law, the local authority issues out notices but after the third notice the issue goes into litigation and since the local authority does not have power in land allocation they lose the case and it becomes a continuous dead end cycle.

5. Lack of education on the benefits of wetlands to the environment

Lack of education or awareness about the benefits of wetlands to the environment is another identified cause of wetland encroachment according to findings by key informant. They noted that the local residents should be continuously educated on the benefits of the natural environment in contrast to development activities that lead to environmental deterioration. Key informants interviewed strongly agreed that being equipped with adequate knowledge would lead to a change in mindset that seeks to balance competing claims of livelihood demands versus the sustained use of natural resources.

7.3 Effects of activities conducted on wetlands by local community villagers

1. Alteration of size and quality wetland sites

Findings from data collected from key informants and mapping through landuse landcover changes reveal that activities carried on wetlands by the local community have detrimental effects to the surrounding ecosystems in that they are compromising the size and quality of these sensitive landscapes. Brick making in Mphego village was also noted as having consequential effects both to the surrounding ecosystem as well as the wetland itself. Effects include water pollution which affects the water quality, dredging out of soil from wetland bodies as well as escarpments leading to land wetland escarpment degradation and destruction of natural vegetation in the process of soil extraction for brick making which affects the ecosystem balance in terms of wetland vegetation inhabitant species as their food web will be disrupted. Findings from data collected also disclosed that Budeli and Mutoti is experiencing dumping of solid waste in some of its wetland bodies which affects the water quality, aquatic life and the aesthetic quality.

2. Conversion of wetland sites to other uses

Alteration of wetland sites through conversion of wetland sites to other uses such as farm land and consequently disappearance was pointed out as another effect of activities conducted on wetlands by local community villagers. Farming as a human activity in Mphego was also highlighted as leading to the conversion of some seasonal inland wetlands to agricultural land leading to the disappearance or drying up of wetlands. It has led to the introduction of new land species that may not harmoniously co-exist with natural wetland vegetation as a result it has resulted in the introduction of some invasive species in the process. The use of fertilizers in the aforementioned has affected the mineral composition of the wetland soil which affects the type of vegetation and how it copes in the new soil environment.

They also noted that in Budeli and Mutoti, land clearing to accommodate recreational facilities have destroyed the natural vegetation and some of the people that visit those areas for tourism purposes dump solid waste such as plastic and metal which may not be biodegradable hence affect the aesthetic beauty of some of these wetlands and harming or interfering with the acquatic life of these wetland systems. Grazing of livestock is another human activity that has led to instances of overgrazing hence affecting the natural vegetation state. Turnaround time for vegetation growth takes long periods of time and this affects the ecosystem in that other wetland organisms that rely on that vegetation for survival will be affected through extinction.

3. Land tenure system

Key findings revealed that land tenure system that allows for cheaper and easy land transactions in Budeli and Mutoti has seen illegal residential development that leads to the destruction and ultimate disappearance of wetlands through the use of impervious building material that prevent water seepage to their foundational structures as well as properties. They also added that some of the development taking place for residential or commercial is not following proper environmental impact assessment procedures; hence these developmental projects have more costs than benefits to the surrounding ecosystem.

7.4 Policy strategies that can be employed so as to mitigate the effects of wetlands encroachment

1. Integrated effort in stakeholder participation in land management in peri-urban villages

Findings from data sources used in the study revealed that there should be an integrated or joint effort in terms of stakeholder participation in land management in peri-urban villages of Nandoni such as Budeli, Mutoti and Mphego. Traditional leaders should work closely with the local authority land custodians such as spatial planners and environmentalists. This concerted effort would be backed up by the Spatial Planning and Landuse Management Act (SPLUMA), Landuse scheme, Spatial Development Framework (SDF), and the Integrated Development Plan (IDP) and avoid illegal land parceling on sensitive ecosystems such as wetlands whose activities that will in turn result in adverse effects that are a threat to the surrounding ecosystem.

2. Legally acceptable enforcement system

Findings revealed that legally accepted enforcement system would avoid bottleneck in enforcement of illegal wetland encroachment activities such as brick making for example which is a mining activity by law and requires certain environmental procedures that are compliant with environmental law. In the case of dispute resolution between the local authority and non compliant wetland encroachers (brick makers) in Mphego village for example regarding notice issuance for non compliance to those engaged in brick-making activities and who have violated the law in terms of an absence of a mining license. The existing litigation process was

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seen to reach a dead end on the issuance of the 3rd notice that does not place value on the local authority's voice when it comes to law in the form of enforcement which results in the local authority losing the case.

3. Participatory forums at village level

Findings from data collected suggests that local community should engage in different participatory forums through their local traditional headsmen such as the Mayor Mahosi forum and Imbizo that preserve conservation of the environment inclusive of sensitive landscapes such as wetlands.

Implications on spatial resilience on ecosystems in peri urban areas

The findings of the study suggest that wetland encroachment on surrounding wetland ecosystems being affected to a greater extent due to various activities such as residential development, farming, brick-making and overgrazing. The spatial resilience of these surrounding wetland ecosystems is being affected adversely by the effects of encroachment activities. These activities are greatly resulting in the conversion of wetland ecosystem into new uses that lead to alteration and consequence disappearance of wetland as it is being practiced at an extensive level in the case of residential development and cropland or farmland. As wetlands are major carbon stores on the earth, their disturbance may release greenhouse gases that contribute the most to global warming. In terms of stakeholder participation, findings suggests a concerted effort between the local authority and the traditional leaders in land management so as to avoid illegal land allocations that result in the disturbance of wetland surrounding ecosystem

8 CONCLUSION AND RECOMMENDATIONS

This study concludes that encroachment of wetlands by various human activities in per urban areas is real and the spatial resilience of surrounding ecosystems is being affected greatly. Land management is an important factor in peri-urban wetland encroachment as it regulates the types of activities that are to occupy certain parcels of land and some that are sensitive such as wetlands. Recommendations made in this study are that:

- Concerted partnership is established between planners, environmentalists, traditional leaders in land allocation issues as each and every party involved works towards the preservation of the natural landscape in the form of proper planning, law enforcement and environmental feasibility.
- Direct engagement with the community in the concerted partnership set up as the community is the end user and need to be made aware of various developmental activities and their effects to the surrounding ecosystem.
- Sustainable practices be adopted that sustain both the community and the environment to reduce the impacts of wetland encroachment by human activities coupled with strong partnerships by community, local leaders and local authority.
- An inclusive approach in land allocation issues between the local authority and the traditional leaders be adopted and practiced.
- Incorporation of community participatory initiatives that raise awareness on wetlands importance and the extent of how human activities compromise wetland habitat quality such as Imbizo and Mayor Mahosi Forum.
- Continual enforcement by the local authority.
- Local community engagements on the best practices that help sustain the environment at the same time that meets their livelihoods.

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