

PROGRAMME

Academic Procession

North West University Anthem

Scripture Reading and Prayer

Pastor Moses Tlalang

Word of welcome and purpose of the Inaugural Lecture

Prof Eno Ebenso

Executive Dean – Faculty of Natural and Agricultural Sciences

Acknowledgement of Guests and Introduction of the Speaker

Prof Helen Drummond

Deputy Dean (Teaching and learning), Faculty of Natural and Agricultural Sciences

Inaugural Lecture

By

Professor Lobina G Palamuleni

BUILDING THE BRIDGE: THE LAND AND WATER BRIDGE

Presentation of Certificate and Congratulatory message

Prof Maryln Setlalto

Deputy Vice-Chancellor: Community Engagement and Campus Operations: Mafikeng Campus

Announcements and Vote of thanks

Prof Eno Ebenso

Grace

Pastor Moses Tlalang

South African National Anthem

Academic Procession

BUILDING THE BRIDGE: THE LAND AND WATER BRIDGE

Inaugural Lecture

Lobina Gertrude Palamuleni

BEd., & MSc. Environmental Science (University of Malawi), PhD in Geography (University of Johannesburg)

1. BIOGRAPHICAL DATA

Professor Lobina Gertrude Palamuleni is a full professor and has served as Head in the Department of Geography and Environmental Sciences; Director, in the School of Environmental & Health Sciences and Deputy Director in the School of Geo-Spatial Sciences. Professor Lobina was born in Mulanje district, Malawi and she is the third daughter in a family of six children; four girls and two boys. She attended her primary and high school education in Malawi before she was admitted to Chancellor College, University of Malawi where she received a Bachelor's degree majoring in Geography in 1991. This was followed with seven years of teaching Geography at different secondary schools in Malawi. She then registered for MSc in Environmental Sciences with Chancellor College (the first cohort of the programme in 1999), and graduated in 2001. A workshop for Geography Educators which was held in Sweden changed her perception about Geography; she was introduced to the concept of land use mapping and change analysis using Remote Sensing tools. Fascinated with the tools, in 2004, she joined the then Rand Afrikaans University (currently University of Johannesburg) and simultaneously registered for a PhD in Geography, with the title: Land Use Change and Hydrological Regimes in the Upper Shire River catchment, Malawi. She is currently registered with the North West University and in the final year of Master of Business Administration degree programme.

In August 2009, she joined North West University, in the Department of Geography and Environmental Science. She calls herself a Geographer! To date, Professor Lobina has supervised and graduated 10 Hons, 11 MSc and 9 PhD students. She has also mentored one post-doctoral fellow. Currently, she has 5 MSc registered students, 2 PhD candidates and one post-doctoral fellow.

Professor Lobina Palamuleni serves as a reviewer to local and international journals including: GeoCarto International, Applied Geography, GIScience Remote Sensing, Remote Sensing, International Journal of Water Resources Development, Physics and Chemistry of the Earth, Environmental Monitoring and Assessment and International Journal of Environmental Research and Public Health.

Professor Lobina Palamuleni is a member of the following professional bodies: Society of South African Geographers, Association of African Remote Sensing of the Environment, Association of American Geographers, IEEE International Geosciences and Remote Sensing Symposium (IGARSS), Member of WaterNet/Water Research Fund for Southern Africa, Environmental Information System and AfricaGIS International Geospatial Society, Organisation for Women in Science for the Developing World.

Professor Lobina Palamuleni has served as an external examiner for various local and international universities in Africa such as University of Kwa Zulu Natal, University of Limpopo, University of Venda, University of the Western Cape, University of Fort Hare, University of the Free State, University of Malawi (Chancellor College and the Polytechnic). She was also a panel member of the Doctoral Review Environmental Science programme at the University of South Africa.

SALUTATION

The Deputy Vice-Chancellor, Campus Registrar & Other Principal Officers, Dean of FNAS & Deans of other Faculties, Distinguished Fellow Professors, Members of Campus Senate, Academic & non-academic colleagues, Invited Guests, Students, Ladies & Gentlemen.

I am most delighted to stand before you on this occasion to deliver my Inaugural Lecture in recognition of my promotion to the rank of full professor: Geography & Environmental Science in 2018 by the North West University, South Africa. It is an opportunity for me to talk about my academic life and to share ideas in my path of scholarship.

2. INTRODUCTION

2.1. Biblical Perspective of Natural Resource Management

Madam Deputy Vice-chancellor, colleagues, ladies and gentlemen, what does the bible say about land, water and pollution? Most popular scripture is the God given right to human beings that whatever He created is for man's benefit and enjoyment.

Genesis 1 vs 26-28: ...let them have dominion over the fish of the sea, over the birds of the sir, and over the cattle, over all the earth sand over every creeping thing that creeps on the earth.....be fruitful and multiply; fill the earth and subdue it....

This verse seems like that gave mankind to do anything that he wants to the planet. Certainly, God did not give man the authority to degrade and destroy the earth. Certainly, God did not give man the authority to degrade and destroy His earth. God asked man to keep it. In Genesis 2 vs 25, God is instructing Adam to keep the garden of Eden.*And the LORD God took the man, and put him into the garden of Eden to dress it and to keep it. Keep (Hebrew shamar) means "to exercise great care over."* In this context, Gods' wish for mankind was and still is to "take care of," "guard" or "watch over" the garden. Our duty on earth is to keep in utmost natural state whatever God created.

The people of the Bible were invariably farmers and shepherds. They relied on the land as a sustaining resource, and they did not “mine” the land to deplete all the resources. Rather, abusing the land was like chopping the leg on which you stand.

*Numbers 35.33-34 has an interesting touch. It reads:
.....Do not pollute the land where you are... Do not defile
the land where you live and where I [God] dwell.*

It seems like the environmentalist's dream verse. Well, actually, the "pollution" and "defilement" refer to ritualistic abuse (committing sins, like murders, on the land), but I think this helps make the case: God's people are called to treat the land as holy. Worship of God means nurturing the land even more than tending a church building.

Leviticus 25 vs 2-5 God is advising us about good agricultural practices - Six years you shall sow your field, and six years you shall prune your vineyard, and gather in its fruit; but in the seventh year there shall be a sabbath of solemn rest for the land, a sabbath to the LORD. You shall neither sow your field nor prune your vineyard. What grows of its own accord of your harvest you shall not reap, nor gather the grapes of your untended vine, for it is a year of rest for the land."

There are a number of verses in the bible that contain the bulk of the environmentally friendly passages and which we can draw lessons from. Maybe if we want to solve the many environmental issues and problems the world is facing today, people need to develop and follow an appropriate “*moral basis*” – the environmental ethic approach. Probably if we behave as good stewards who have been appointed by God to manage the “*domestic environmental concerns*” of our planet earth, we would do things differently. But for the purpose of this lecture, let me not provoke the minds of those with a contrary view.

2.2. Broad Research Concepts

The first part of my lecture is a discussion of the broader understanding of the different concepts:

Land use and land cover mapping, Land use change and hydrology and Water resources management.

The second part will be a demonstration of the research that I have been doing and the little contributions that I have made thus far.

The third part will be a forward look at my future research ambitions.

2.2.1. Land Use and Land Cover Mapping

Land cover, i.e. the composition and characteristics of the land surface elements, is the key environmental information. Identifying, delineating and mapping land cover is important for resource management and planning programs. Regular review of land cover mapping indicates the significance of the periodic determination of land cover distribution over an area of interest for scientific research, resource management, planning and policy purposes [1]. Fundamental to modelling the Earth as a system depends on the land cover mapping process. This implies that sustainable livelihoods and food security depend on the effective management of land resources. Hence, land cover mapping forms a reference base for resource managers in their decision-making processes to guide rural and urban growth, determine changes to natural resources, and develop spatial trend analyses [2]. Documenting the distribution of land cover types at a catchment scale is the foundation for applications not only in the study of surface water redistribution and run-off but also in monitoring environmental trends.

2.2.2. Land Cover Change and Hydrology

Rapid changes in land cover have a significant impact on conditions of catchment ecosystems. Accurate information on the status of and trends in land cover changes is needed to develop strategies for sustainable development and to improve the livelihood of communities. The ability to monitor catchment land cover changes is highly desirable by both local communities and policy decision makers. With increased availability and improved quality of multi-spatial and multi-temporal remote sensing data as well as new analytical techniques, it is now possible to monitor catchment land cover changes and their potential hydrological responses in a timely and cost-effective way.

Land cover changes could be attributed to both climatic and anthropogenic factors such as climate variability, deforestation, erosion due to overgrazing, and urbanisation [3]. The conversion of land to cropland for food security is a cause of major concern. Forest clearance has resulted from an increased demand for forest products such as fuelwood, commercial logging and construction materials. Many current land cover practices in most African catchments have the potential to adversely affect and degrade the environment with respect to forests, soil, water, and biodiversity resources.

Precipitation and land hydrological processes maintain the water balance in a river basin. Land surface performs a role in the hydrological cycle, as water availability is generally a consequence of precipitation redistributed into evaporation, run-off and soil moisture storage [4]. There are many connections between land surface characteristics and the water cycle. The modifications of natural vegetation cover and soil conditions usually lead to changes in rainfall runoff characteristics of the catchment area, which consequently change river flow regimes [5]. Firstly, land cover can affect both the degree of infiltration and run-off following precipitation events. Secondly, the degree of vegetation cover and the albedo of the surface can affect rates of evaporation, humidity levels and cloud formation. Any change in land cover will have correlated effects in the hydrological regimes, and possible impacts on the habitat and ecological communities [6; 7].

2.2.3. Water Resources Management

Water resources management focusses on sustainable management of water resources encompassing both surface water and ground water resources. The principles of water resources management include quality management, water conservation, water demand management, water supply and sanitation technologies.

Water is the most significant natural resource across the Earth and it has recently become a scarce resource worldwide [8; 9; 10]. The increasing pressure on global water resources is impacting heavily our environmental, social, and economic well-being [11]. Nonetheless, water scarcity is caused by an ever-increasing water demand, which is mainly driven by an increase in population, urban development, food and energy security policies, and macro-economic processes such as trade globalization and trends in water resource utilization [11]. The World bank, 2017 estimates that with current practices and global population growth, the world will face a 40% shortfall

between forecast demand and available supply of water by 2030. Furthermore, chronic water scarcity, hydrological uncertainty, and extreme weather events (floods and droughts) are perceived as some of the biggest threats to global prosperity and stability.

Water scarcity can be found to be either economically or physically scarce. Physical water scarcity thus refers to water shortages caused by different environmental factors. Causes of physical water scarcity may be natural processes or by anthropogenic activities, such as water pollution through acidic mine sewages, or natural processes like seasonal droughts. By 2025, about 1.8 billion people will be living in regions or countries with absolute water scarcity. Economic water scarcity can be defined as lack of access due to economic barriers preventing efficient water supply. According to Falkenmark et al., [12]; Sullivan et al., [13]; Winpenny, [14], countries which are experiencing economic scarcity do suffer from poor service delivery of water caused by damaged, inadequate, old water infrastructure. For example, studies in economic water scarcity in South Africa has revealed that aging, poor quality and poorly maintained infrastructure is contributing to high levels of water wastage and pollution of rivers and groundwater with sewerage. Of the 144 municipalities with water supply requirements, 33% are dysfunctional [15]; nearly 25% of SA's wastewater treatment facilities are in "critical state". South Africa treats only 54% of its municipal wastewater [16].

However, from a geographical perspective, Madam Deputy Vice –Chancellor, colleagues, ladies and gentlemen, my focus has been on the physical water scarcity: water quantity which is the supply side of management and water quality assessments. Physical water scarcity can be divided into two main concepts: demand-driven scarcity (water stress) and population-driven scarcity (water shortage) [12]. Demand-driven scarcity is measuring by examining how much water is being drawn from rivers and aquifers, known as use-to-availability index [10; 12].

Most sub-Saharan African countries face physical water scarcity and it has been documented that in such areas more than 60% of river flows are withdrawn. South Africa's water consumption is about 235L/capita/day well above the global average of 175L/capita/day. South Africa is a semi-arid country and is faced with a scarcity of freshwater resources. South Africa receives an average rainfall of about 450mm which is well below the world average of about 860mm per year. Water challenges in the country range from security of supply, environmental degradation to resource

pollution [17]. Water availability in South Africa is faced with three major challenges: uneven distribution and seasonality of rainfall, relatively low streamflow in rivers most of the time and points of use remote from the country's larger water courses.

3. CAREER JOURNEY: HOW DID I GET HERE?

Before I proceed, I would like to divert and answer the question: How did I get here?

A summary of my schooling and career began some few years back when I started primary school at Malinki primary school, a few kilometres from Chileka International Airport. During weekends, my late father would take us to the airport to see airplanes. Madam Deputy Vice-chancellor, colleagues, ladies and gentlemen, that time our airport was graced with the big airlines: British Airways, Dutch airlines etc. Seeing the cabin crew, especially the air hostesses made me think that this will be my career in future, air hostess. After sharing with my friends, one of them told me that you need to excel in Geography so that you are aware of the different countries, cities, issues of time difference and so on. My passion for the subject Geography grew and I was determined to work harder in that subject. However, when I shared my career aspiration with my father (who had travelled the world) he laughed and said "*do you want to be serving people in the plane?*" I was taken aback but my interest in Geography was already deep and there was no turning back. Later whilst in secondary school and during my undergraduate, I came to know that Geography is not a one stop shop. It is very diverse such that besides being an air hostess, I could explore the other avenues. Teaching the subject was one of the options. I taught at high school for about 7 years before pursuing Masters in Environmental Sciences and later PhD in Geography. I joined the University of Malawi, Chancellor College in 2001 as a Lecturer.

Spatial geography is the study of geographical features across space and time. My inaugural lecture focuses on a multidisciplinary perspective of two important natural resources: land and water to help us identify and understand the spatial and temporal consequences of their interactions. At Masters level, I focused on water resources particularly water quality in peri-urban areas. This study set the scene for me as a researcher and later as an academic. Findings of this research were presented at the 3rd WaterNet/WARFSA conference in Cape Town, South Africa. I was informed that all papers presented at the conference will be published in a special issue –Physics and Chemistry of the Earth by Elsevier publishers. Madam Deputy Vice-Chancellor, I was scared

because I had never written a paper for publication before. However, I took the challenge and am proud to say that my first publication came out in 2002 and it is the highly cited paper till today (over 70 citations, am still counting!). This was the beginning and let me quote Israelmore Ayivor who said: *Every big castle was once started with a single block; despise no small beginnings. A little step taken every day builds up the hope of greater accomplishments. Do something every day!*” The Cape Town conference was a motivation that “*I can do all things through Christ who strengthens me*”.

At PhD level, difficult questions had to be asked. It was not just a matter of water quality analysis. Integrated and multidisciplinary approach were the buzz words then and my thinking was to integrate land and water using modern technologies of remote sensing.

Ian Somerholder once said that *the environment is in us, not outside of us. The trees are our lungs and the rivers our bloodstream. We are all interconnected, and what you do to the environment, ultimately you do to yourself.*

Whatever humans do to the environment; at some point it will come back to haunt us – either positively or negatively. I wanted to explore the connection between land use change and water quantity. My PhD supervisor, Prof Harold Annegarn used to ask me: if you assess the land cover changesso what? I soon realised that my PhD was engrossed in my response to the question.....“*so what.*”

4. BRIDGING THE BRIDGE – THE “SO WHAT” BRIDGE

The next part will describe my professional journey through the subjects of Applied Remote Sensing, Geographical Information Systems and Water Resources. Philippians 1 vs 6 says: *...being confident of this very thing, that He who has begun a good work in you, will complete it until the day of Jesus Christ*”. Allow me to say the he who has begun a good work of water resources management will complete it until every human being has adequate and sufficient water. The “*so what*” bridge that I have been trying to build for the past years, construction is still underway.

4.1. Contributions to Scientific Knowledge

Madam DVC, permit me to indicate that over the past years, research and innovation as well as publication has been at the forefront of my academic career. I have realised that research has to be meaningful and it has to address specific societal needs.

4.1.1. Land Cover Mapping

With reference to land cover mapping, the focus of my research work has been on the drivers of landscape change. Land cover maps provides a better understanding of the impacts of natural phenomena and general human use of the landscape. Land cover maps represent spatial information on different types (classes) of physical coverage of the Earth's surface, e.g. forests, grasslands, croplands, lakes, wetlands etc. Dynamic land cover maps include transitions of land cover classes over time and hence captures land cover changes. Remote sensing technologies can be used to document land use trends and changes. With this information, managers can evaluate past management decisions as well as gain insight into the possible effects of their current decisions before they are implemented.

Most fundamental to land cover mapping is adherence to the Sustainable Development Goal 15: Life on Land which entails the *“protection, restoration and sustainable use of terrestrial ecosystems, sustainable management of forests, combating desertification, and halt and reverse land degradation and halt biodiversity loss”*. Madam DVC, the United Nations noted that from 2000 to 2015, more than one fifth of the Earth’s total land area was degraded, largely due to human-induced processes, such as desertification, cropland expansion and urbanisation. During the same period, there were significant productivity declines in land cover, with grasslands incurring some of the greatest losses. The targets of Sustainable Development Goal 15 are unlikely to be met; land degradation continues, biodiversity loss is occurring at an alarming rate, and invasive species and the illicit poaching and trafficking of wildlife continue to thwart efforts to protect and restore vital ecosystems and species. Madan DVC, ladies and gentlemen, land cover data and maps are meant to better understand the impacts of natural phenomena and human use of the landscape. Maps can help managers assess urban growth, model water quality issues, predict and assess impacts from floods and storm surges, track wetland losses and potential impacts from sea level rise, prioritise

areas for conservation efforts, and compare land cover changes with effects in the environment or to connections in socioeconomic changes such as increasing population.

My first study of land cover mapping was funded by Deutscher Akademischer Austausch Dienst (DAAD) through the African Network of Scientific and Technological Institutions (ANSTI) for the PhD fellowship. The study was to map land use and land cover dynamics in the Upper Shire river catchment in Malawi. The work was an attempt to promote innovative automated land cover mapping based on remote sensing information to generate data products that are both appropriate to, and usable within different scientific applications in developing countries such as Malawi. Findings of the study revealed degradation of woodlands due to increase in demand for forest resources and expansion of agricultural land. Madam DVC, am happy to report that this study was one of the baseline studies conducted in Malawi which adopted the hierarchical legend structure determined by the Food and Agriculture Organisation (FAO) Land Cover Classification System (LCCS) to label land cover variables [18]. The classification system forms the basis to achieve legend harmonization within Africa and on a global scale. Currently, the system serves as an internationally agreed reference base for land cover mapping. The highlights of the study include the published work in GeoCarto International in 2010 [19] and the publication received international recognition where researchers from the USA requested for classification data for their project which was funded by the World Bank on land cover mapping for Malawi.

Land cover mapping can also be targeted at specific sector of the environment. Life on our planet is entirely dependent on the ecosystem services. Ecosystem services are defined as the benefits derived from nature, such as food, clean water, flood control, climate regulation by forests and nutrient cycling [20]. However, growing population pressure and the drive for economic growth make human beings themselves contributors to damaging ecosystems and their services thereby causing negative feedbacks [20; 21]. Mapping ecosystem services helps in supporting sustainable resource management. Studies indicate that mapping ecosystem services is useful for making decisions related to land-use and management, identify trade-offs and come up with win-win situations between ecosystem services [22; 23]. This is in line with Sustainable Development Goal 15 whereby biodiversity declines are negatively impacting on rural livelihoods. I should mention here that most rural communities depend on the natural environment for sustenance and services such as food, fodder, timber and firewood as well as other services such as erosion control and soil

quality improvement. In the case of ecosystem services, an inventory of provisioning ecosystem services using participatory Geographical Information Systems approach was done. Findings indicated that between 1984 and 2013, woodlands have declined by 88.5%, shrublands have declined by 16.7%, agricultural areas have increased by 44.3% and urban areas have increased by 143%. The declining woodlands, forests and shrublands have implications on the availability of provisioning services that communities derive from this ecosystem (Figure 1). The emphasis is the integration of remote sensing techniques for land cover mapping and change detection to capture ecosystem degradation in order to achieve the outcome of an ecologically sustainable society.

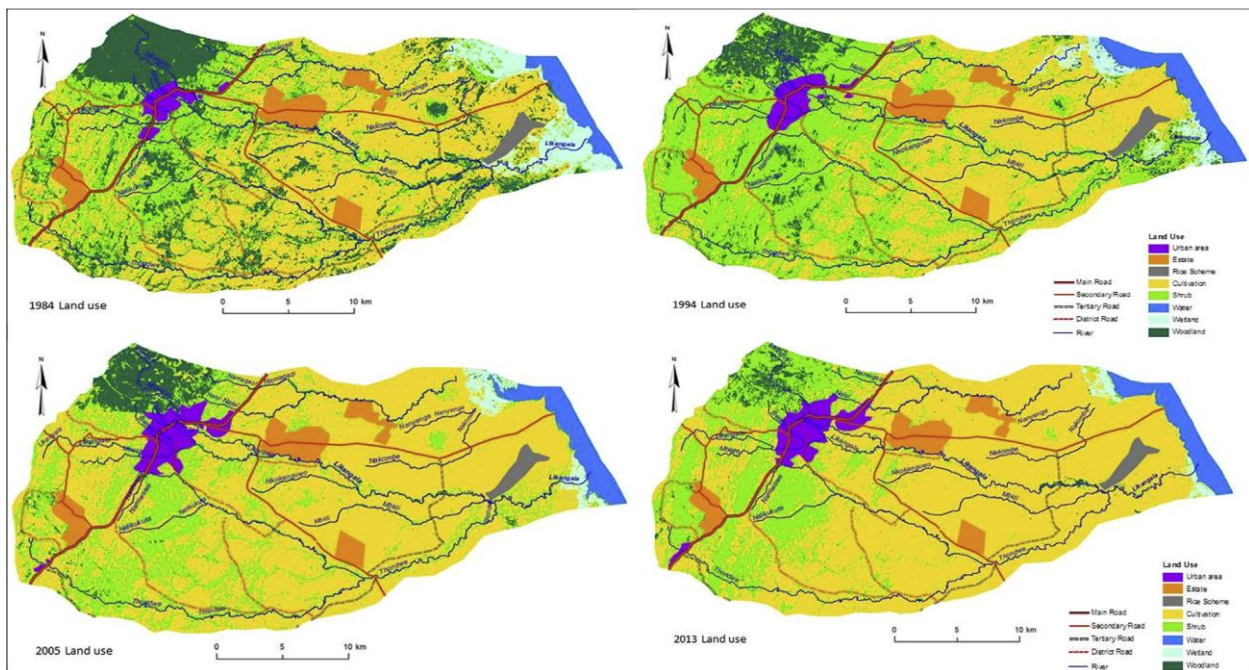


Figure 1: Land use maps in 1984, 1994, 2005 and 2013

Besides, the work on ecosystem services was published in Applied Geography (2.56 impact factor), and the study created a lot of international interest. Madam DVC, colleagues, ladies and gentlemen, this work was acknowledged by the Red List of Ecosystems Categories and Criteria (2016) by International Union for Conservation of Nature and Natural Resources (IUCN) as among the few projects that have evaluated global ecosystems. This Madam DVC is an indication that research being conducted at NWU has a global impact.

The work on land cover mapping has been published in:

1. Palamuleni, L.G., Annegarn, H.J., Landmann, T. (2010): Land cover mapping in the Upper Shire River catchment in Malawi using Landsat satellite data. *Geocarto International*, Vol. 25 (7), 503-523
2. Pullanikkatil, D. Palamuleni, L. G. and Ruhiiga, T.M. (2016). Land use/land cover change and implications for ecosystem services in the Likangala River Catchment, Malawi. *Physics and Chemistry of the Earth* <http://dx.doi.org/10.1016/j.pce.2016.03.002>

4.1.2. Land Cover Change and Hydrological Regimes

My research on land cover mapping, land cover change detection and implications on the hydrology of catchment areas has covered Malawi and several catchment areas in South Africa where the concern is establishing synergies between man's constant interaction of the land and the associated consequences. Landscape changes have important environmental consequences at local, regional and global scales. At the regional and global scales, these changes have profound implications for global radiation and energy balances, alterations in biogeochemical cycles, perturbations in hydrological cycles and loss of biodiversity at genetic and species levels [24]. At the local scale, changes in land cover affect catchment runoff, microclimatic resources, groundwater tables, processes of land degradation and landscape level biodiversity. All these have direct impacts onto the livelihoods of local communities. These multifaceted environmental impacts can affect, immensely, food security and sustainable development [25]. Studies at a local scale of land cover can also help to reveal general principles to provide an explanation and a prediction of new land use cover changes (LUCCs) at larger spatial scales especially in semi-arid areas. It should be noted Madam DVC that most of these land cover change detection has been done at a local scale, however, they have regional and global implications. Some of these catchment areas have transboundary associations such that what happens upstream, might have negative or positive consequences downstream.

Madam DVC, colleagues, ladies and gentlemen, the distribution, abundance and quality of resources are in constant alteration, largely owing to land use activities and climate change. We have remote sensing technologies that are able to offer a synoptic view and repeated coverage of the Earth surface which have enabled us to map these resources in both space and time. As I mentioned before, mapping of land uses and the general land covers is critical for sustainable

natural resource management; let me be biased here, ...*for water resources management*. I conducted a study in the Upper Shire River catchment in Malawi to investigate the impacts of land cover changes in the degradation of hydrological regimes. The study utilised remote sensing techniques to inventory temporal and spatial changes of land cover in the catchment. Hydrological data were analysed to reveal the alterations and trends for two periods; 1989 and 2002. The study revealed significant changes in magnitude and direction that have occurred in the catchment between 1989 and 2002, mainly in areas of human habitation. Trends in land cover change in the Upper Shire river catchment depict land cover transition from woodlands to mostly cultivated/ grazing and built-up areas (Figure 2).

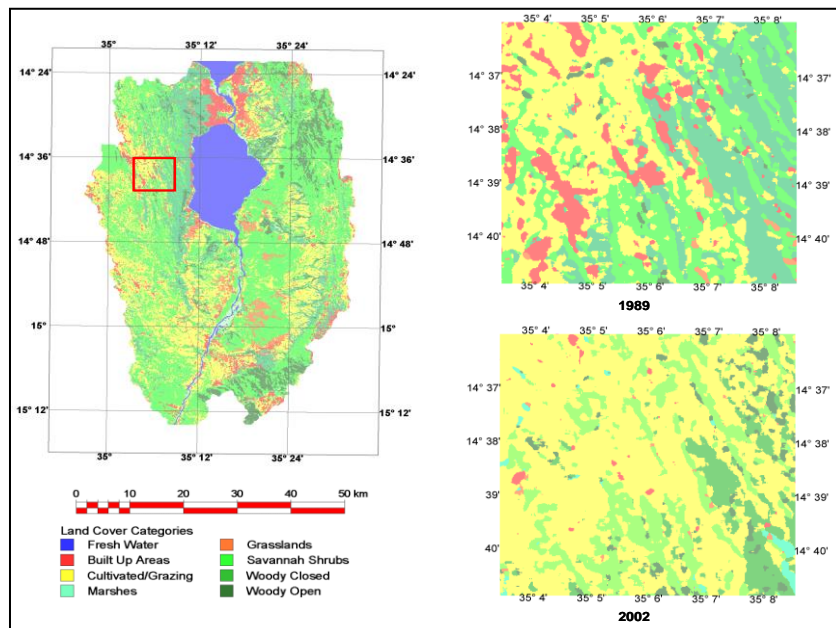


Figure 2: Expansion of cultivated or grazing areas into predominantly savanna areas

The land cover mapping showed that 23% of the land was covered by agricultural land in 1989. Subsistence agricultural area has increased by 18%, occupying 41% of the study area in 2002. The effects of the derived land cover changes on river flow in the Upper Shire river were investigated using the semi distributed soil and water assessment tool (SWAT) model. River flows were found to be highly variable and sensitive to land cover changes. Figure 3 shows time-series of cumulative surface run-off for the period of 1977–1981 for the study area catchment are presented. The simulations were based on 1989 and 2002 land cover data. As depicted, the curve for 2002 land

cover data simulated surface runoff plots above that of 1989 curve. Such increase in surface runoff is attributed to land cover changes.

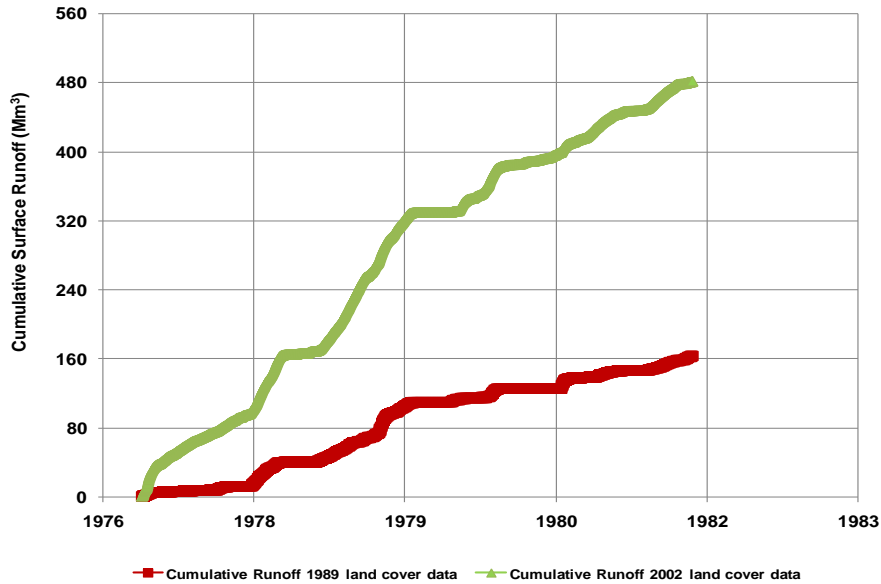


Figure 3: Time-Series of Cumulative Surface Runoff as Simulated Using 1989 And 2002 Land Cover Data

The Masters’ study by Mr T Kabanda is a project I designed based on lessons learnt from my PhD work on the relationship between land cover change and streamflow dynamics. The motivation for this study was that catchment land cover changes remains a local problem but it has a global consequence. Kabanda and Palamuleni [26] looked at land cover changes in the Harts catchment from 1990 to 2010. The study integrated remote sensing, geographical information systems and statistical methods to document alterations and trends in land cover and the implications on flooding behaviour of the Harts catchment. Results revealed a positive trend in discharge in the Harts River coincides with major changes in land cover over the study area. The LULC changes showed a decrease of vegetation cover, while barren land increased. Research findings indicate that the modifications of natural vegetation cover have led to modified runoff production and consequently to changing flow regimes in the Harts catchment. The drivers of vegetation cover destruction reveal a harsh reality of the over dependency of most rural communities on natural resources. Natural vegetation is the primary source of energy, food resources and building materials. However, the conversion of the natural vegetation from a variety of natural or

anthropogenic factors, disrupts the hydrological cycle and consequently the runoff response of the area [27].

I would also like to emphasise that land cover change studies do not only focus on the conversion or transformation of existing natural environment. These studies can also focus on specific aspects of the environment such as changes in vegetation density which are important parameters to the understanding of some of the drivers of change and the positive or negative impacts likely at a local scale. Vegetation density describes the quality and quantity of the number of individuals of a given species that occurs within a given sample unit or study area. Noticeable in most rural communities is the decreasing trend of vegetation density due to both climatic and anthropogenic factors such as climate variability, deforestation, erosion due to overgrazing and urbanisation [3]. The irony about this is that rural livelihoods are linked to the natural resources.

Palamuleni and Turyahikayo, [28] assessed vegetation density in the Upper Molopo River catchment, South Africa. This project was motivated by the fact that in arid and semi-arid environments like the rest parts of South Africa, the state of vegetation density in catchments is an important indicator of the state of the environment. Climate variability coupled with different anthropogenic activities could affect vegetation cover at varying levels. The objectives of this study were to: (i) quantify vegetation density trends using multi-temporal Landsat data; (ii) identify and map various land use types and (iii) establish relationships between anthropogenic activities, climate variability and vegetation density change. A substantial change in vegetation densities were observed during the study period, high and medium vegetation density had shown decreasing trends with a simultaneous increase in low vegetation density extent (Figure 4). The results ascertain that the spatial distributions of vegetation density change during the different years and seasons in this region are a result of mainly anthropogenic activities and climatic factors. The identified trend calls for short-term and long-term strategies to be developed to ensure sustainable land management in the catchment area since the structure and distribution of vegetation *vis-à-vis* density is critical in the functioning of catchments that provide many important ecosystem services in arid regions.

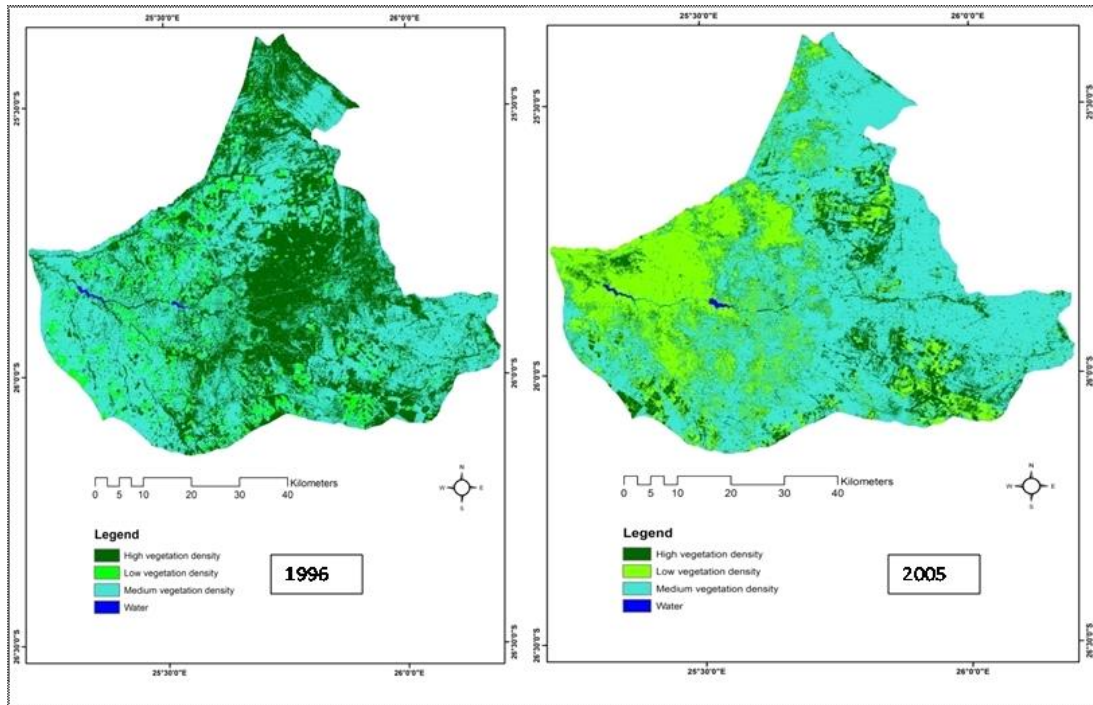


Figure 4: Vegetation density between 1996 and 2005

Madam DVC, ladies and gentlemen, land cover change analysis have applications not only on vegetation density and water resources. According to Lui et al. [29], timely and accurate land cover maps are required to understand the relationships and interactions between human and natural phenomena. The intentions of land reform programme, land restitution and resettlement were/are meant to produce results that have noticeable effects on the pre-1994 apartheid social structure. Questions were asked on the effect of land restitution and productivity. A study was conducted to investigate the effects of the South African land reform policy on land use and land cover change on a land restitution project. Land cover dynamics revealed declining trends in post-transfer activities with agricultural cropland decreasing tremendously during the study period. Inadvertently, land under fallow and shrubs increased. This accelerated decline of agricultural activity is mainly attributable to change of land ownership and management skills from the commercial farmers to the inexperienced land claimants. The fear of disrupting large scale commercial agriculture in any radical land re-distribution programme means that the masses of the poor remain poor and landless. Recommendations were made to first prepare and train the land claimants to ensure that access to land is coupled with the know-how for progressive productivity.

A few research publications resulting from these researches are outlined below:

1. Palamuleni L. G., Ndomba P. M., and H. J. Annegarn (2011) Evaluating land cover change and its impact on hydrological regime in Upper Shire river catchment, Malawi *Regional Environmental Change* 11:845–855 DOI 10.1007/s10113-011-0220-2
2. Lidzhegu Z. and L.G. Palamuleni (2012) Land Use and Land Cover Change as a Consequence of the South African Land Reform Program: A Remote Sensing Approach, *Journal of Food, Agriculture & Environment* 10 (3&4): 1441-1447
3. Kabanda T.H. and L.G. Palamuleni (2013) Land use/cover changes and vulnerability to flooding in the Harts catchment, South Africa, *South African Geographical Journal*, 95:1, 105-116, DOI:10.1080/03736245.2013.806165
4. Palamuleni, L. G. and A. Turyahikayo (2015), Vegetation density assessment in the Upper Molopo River Catchment, South Africa, *Journal of Food, Agriculture & Environment* Vol. 13(2):190-196

Madam DVC, the outputs from these investigations were not limited to just publications but it is important that I mention here that one MSc Geography (Mr Z. Lidzhegu) and two MSc Environmental Sciences (Ms A. Turyahikayo and Mr T Kabanda) were produced.

4.2. Water Resources Management

With reference to environmental science, my research work is centred on water resources management. As mentioned already, the paramount issue about water is its availability, quality and management. In this sector of my research, I have been guided by the Sustainable Development Goals that were adopted by the United Nations General Assembly with the 2030 Agenda for Sustainable Development. Reference to the need for the provision of Clean Water and Sanitation (Water production, water treatment, water distribution and use) “SDG 6” and responsible production and consumption that involves agriculture and farming for food production). My research is basically centred on the rationale for Integrated Water Resources Management (IWRM) approach which is an internationally accepted method for efficient, equitable and sustainable development and management of the world’s limited water resources and for coping with conflicting demands.

Madam DVC, ladies and gentlemen, I do not consider land, water and biodiversity management as separate activities. Whatever humans do on the catchment, land use and land cover activities,

have considerable impact on the condition of rivers and water bodies. Catchment disturbances such as expansion and intensification of agriculture, urbanisation have added additional stress to freshwater ecosystems via altered sediment supply, degraded water quality, removal of riparian vegetation and introduction of exotic species [30]. Luna Leopold once said and I quote: *Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land.* Within the umbrella of water resources management, my research has focussed on water quality analysis and characterisation of factors contributing to the state of water in most South African rivers. The linkages between what humans are engaged with in the catchment areas and how such activities impact on water quality.

4.2.1. Water Quality Research

Madam DVC, colleagues, ladies and gentlemen, my research interests are multi-disciplinary cutting across land cover mapping and change detection with special interest in applied remote sensing and Geographical Information Systems for water resources management and monitoring. I started my research career by determining the effect of sanitation facilities, domestic solid waste disposal and hygiene practices on water quality in Malawi's urban poor areas. This study was driven by the State of the Environment report for Malawi which alluded to the problem of household water quality in major cities of Malawi. Noticeable is the lack of documentation on the levels and causes of water pollution particularly in peri-urban areas so that meaningful interventions can be adopted. The main objective of the study was to determine the causes and extent of water pollution in South Lunzu Township in the City of Blantyre. Specifically, the study was aimed at determining the types of water pollution, their levels and identifying the factors which have led to the degradation of water resources in the different sources. Water samples collected from the major sources of domestic water supply showed that there are variations in the levels of water pollution between the ground water and surface water sources and between the wet and dry season. Findings indicate that water resources have been polluted by lack of sanitation facilities, indiscriminate disposal of waste and the institutional set-up governing the provision of services in the area. To a greater extent, whatever is happening on the catchment areas of water sources, has a major bearing on the quality of water. This is the pioneer work that I shall forever keep blowing my trumpet about. My first ever published work in Physics and Chemistry of the Earth in 2002 and still receiving international recognition with over 70 citations.

The PhD degree “*Mapping Ecosystem Services in the Likangala river catchment*” of Deepa Pullanikkatil was awarded in 2015. One of the objectives of the study was to assess the impact of land use activities on water quality in the Likangala River catchment, Southern Malawi. The river profile consists of several land uses including agriculture, urban settlements, wastewater treatment plant and fishing. Water samples collected during the dry and wet seasons at locations chosen on the basis of dominant land use, were analysed for physical, chemical and biological contamination. Results revealed that total coliforms increased by 176.1% and *Escherichia coli* counts increased by 157% downstream of urban areas, these levels being above the permitted local and international standards. Deforestation on Zomba Mountain, soil disturbance at agricultural estates and rice farming activities may also be contributing to increasing turbidity in the water at several sampling points. Phosphates increased downstream of urban areas and agricultural estates. This is suggestive of urban pollution from households, domestic wastewater and fertiliser runoff from agricultural estates. Releases from the wastewater treatment plant, domestic waste, hospital waste and small industries may have contributed to the increase in iron concentrations in the river downstream of urban areas. This study revealed correlations between systems of land use and water quality and therefore calls for a holistic approach to management of the Likangala River. The study concluded that human activities have affected water quality in many river catchments worldwide including the Likangala river. Similarly, Hellar-Kihampa et al. [31] concluded that the Pangani River, Tanzania, had the worst water quality in the Moshi, Arusha and Kilimanjaro region, with the highest levels of Na⁺, K⁺, Mg²⁺, HCO₃⁻ and F⁻, the presence of these contaminants being as a result of human activities.

Land use within catchment areas has great impacts on the water quality of water bodies. This arises as a result of the process interactions between land and water, which in turn create symbiotic relations across time. Understanding these process interactions provides the theoretical base for investigating land use/land cover change under the parallel impact of natural forces and human activities. Water quality may degrade due to changes in the land use patterns within the catchment as human activities increase [32; 33; 34]. Changes in land use and land management practices are critical in influencing factors behind the alteration of the hydrological systems. These in turn may lead to changes in runoff [35] as well as the water quality [36].

In the case of South Africa, similar trends of water quality degradation due to land use activities have been identified. A PhD thesis “*Dynamics of Ephemeral Ponds and Suitability for irrigation in the Vryburg District, South Africa*” examined the relationship between land use changes and water quality parameters in ephemeral ponds. This study was motivated by the semi-arid environment of the North West Province with reference to the amount, timing and distribution of rainfall which is irregular while water accessibility is a key factor in production. In the study area, ephemeral ponds form during the wet season. Ephemeral ponds are small, isolated deep depressions that only fill up during the short rainfall events. They are water bodies that occupy depressions in the local terrain and are associated with impeded drainage. The longevity of these ponds varies between a few days to several months, depending on location, surface area, volume of water stored, and mean depth. Results revealed a reduction in grass cover, whereas built-up areas increased at the expense of bare land. All the values for the physical characteristics were higher than the recommended Department of Water Affairs (DWAF) and Food and Agriculture Organisation (FAO) limits, but chemical parameters, except cadmium, were within limits. Regression showed that bare areas have a positive effect on *Escherichia coli* (E. coli) in ephemeral pond water. According to the regression analysis model, grass cover does not have effects on cadmium concentration in the pond water ($p < 0.849$; $R^2 = 0.45$). Also the presence of cadmium in pond water does not depend on bare area. According to the coefficient of determinant value, the model is poorly suited for the data ($R^2 = 0.45$). Table 1 shows the regression models for land cover and water quality. This study established that in the sub-catchment areas of ephemeral ponds there are many land uses, such as livestock grazing, crop farming, mining, and built-up areas. These activities affect the quality and quantity of ephemeral pond water. In general, the ephemeral pond water quality is affected by land use. The research has found that some ephemeral ponds are of good water quality and can be used to irrigate short, seasoned crops or supplementary dry spells during the cropping season. This can help to improve food security in rural, semi-arid regions.

Table 1: Regression models for land cover and water quality

| Water Quality Parameter | Model Equation | R ² Value | P-value |
|--|---|----------------------|---------|
| Nitrate(NO ₃ ⁻) | NO ₃ = -5.317 + 0.026 GRASS + 0.041 FRESH WATER + 0.036 BARE | 0.886 | 0.422 |
| Electrical Conductivity(EC) | EC = 182.264 + 6.949 GRASS + 2.857 FRESHWATER - 0.378 BARE | 0.779 | 0.576 |
| Sodium (Na ⁺) | Na = 71.408 - 0.137 GRASS - 0.264 FRESHWATER - 0.146 BARE | 0.918 | 0.360 |
| Cadmium (Cd) | Cd = -0.015 + 0.00 GRASS + 0.00 FRESH WATER + 0.00 BARE | 0.449 | 0.849 |
| Ecoli | Ecoli = -544.259 + 5.986 GRASS + 4.224 FRESHWATER + 2.735 BARE | 1.00 | 0.006 |
| GRASS=vegetation use, FRESHWATER=Fresh water use, BARE= Bare areas | | | |

This work resulted in the publication:

Asare, F., Palamuleni, L.G. and T.M. Ruhiiga (2018) Land Use Change Assessment and Water Quality of Ephemeral Ponds for Irrigation in the North West Province, South Africa, *International Journal of Environmental Research and Public Health* 15:1175; doi:10.3390/ijerph15061175

The doctoral degree: *Spatio-Temporal characterisation and pollution sources apportionment in the Klip River catchment, South Africa*, of Tafadzwa Marara was awarded in 2018. One of the objectives of the study was to assess the impact of several land uses - discharge from mines, industry, urban runoff and the wastewater treatment plants along the Klip River catchment on the water quality to ascertain whether the water is suitable for its designated uses (domestic, industrial, agricultural and recreational). The Klip River, owing to the diverse nature of land use activities in the catchment area, has been classified as the most heavily impacted river in South Africa. Water samples were collected from the 3 sub-catchments in the Klip River, also paying attention to the land use patterns. The main land uses identified were urbanisation, mining, agriculture and industrial areas. Water samples were collected at 12 points along the Klip River, monthly from February 2016 to January 2017 and analysed for heavy metal pollution using Inductively Coupled Plasma Mass Spectrometry (ICPMS). The environmental risk assessment was done using the Heavy Metal Pollution Index (HPI), Potential Ecological Risk Index (PERI) and the

Comprehensive Risk Index. Findings revealed that the HPI for aquatic, domestic and agricultural uses were far above the critical index rendering the Klip River unfit for domestic and agricultural uses; and sustaining aquatic life. Furthermore, at a majority of the sampling sites along the profile of the Klip River, the PERI was very high suggesting that there is a serious threat to ecological communities. The study concluded that there is a significant threat to ecological communities in the Klip River from heavy metals. The heavy metals emanating from the anthropogenic activities along the river have a bearing on the quality of water resources. The anthropogenic sources of heavy metals include untreated and partially treated wastewater discharges, industrial effluents, agricultural runoff, mining effluents and storm runoff [Nouri et al., 2006, 2008; Reza and Singh et al., 2010]. The study recommended development of programs that are aimed to rehabilitate and restore the Klip River.

The work has been published in the accredited and peer reviewed article in *Physics and Chemistry of the Earth*: T. Marara and Palamuleni, L.G. 2019. An environmental risk assessment of the Klip river using water quality indices, *Physics and Chemistry of the Earth*, <https://doi.org/10.1016/j.pce.2019.09.001>

4.2.2. Groundwater Assessments

Madam DVC, colleagues, ladies and gentlemen, I would like to bring to your attention the fact that in South Africa, there is a major concern over water resources. The country is a semi-arid, water stressed country with a mean annual rainfall of about 450mm which is way below the world average annual rainfall of about 860mm. Based on the current usage trends, it was estimated that water demand in South Africa would exceed availability of economically usable water resource by 2025 [37]. Groundwater has become an alternative source of water in South Africa and the North West province in particular. Surface water in the North West Province of South Africa is limited and groundwater is the only reliable source of water supply [38]. More than 80% of rural communities in this province depend on groundwater as only source of water supply [39].

Groundwater is an essential part of the hydrologic functions and an important element for socio-economic development. Groundwater plays significant role in arid and semi-arid regions worldwide by providing for both human consumption and the preservation of the ecology. The semi-arid upper Molopo River catchment (UMRC) is no exception. Madam DVC, colleagues,

ladies and gentlemen, groundwater is an important resource for the province, and the South African National Water Act (No. 36 of 1998) supports the principles of Integrated Water Resources Management, where a holistic approach is employed to address all the aspects of the water cycle. Therefore, the groundwater resource is no longer considered as stand-alone resource from other water resources, ecosystem needs, or from the requirements of the greater user community [40].

I have conducted two studies as far as groundwater is concerned. The motivation for the studies was to contribute towards the national water resources goal by suggesting reliable methodology for monitoring trends in groundwater resource and sustainable utilisation of the resource. Levy and Xu, [41] noted that 65% of the country's population which is dependent on this resource has recently been experiencing serious shortage of this resource. A shortage of water in the arid and semi-arid regions has been attributed to their unsustainable utilization and management [42; 43].

The first study on groundwater resources was an honours project carried out under my supervision by Ms M Akoth on the Physico-Chemical and Microbial Analysis of Selected Borehole Water in Mahikeng, South Africa. This project was an assessment of microbial and physicochemical qualities of borehole water in the rural environs of Mahikeng town. The study was carried out on the background that groundwater is generally considered a "safe source" of drinking water. We wanted to ascertain the quality of the water knowing that most rural communities depend on this resource for consumption and other domestic uses. The study aimed at determining levels of physicochemical (temperature, pH, turbidity and nitrate) and bacteriological (both faecal and total coliform bacteria) contaminants in drinking water using standard microbiology methods. Furthermore, identities of isolates were determined using the API 20E assay. Results were compared with World Health Organisation (WHO) and Department of Water Affairs (DWAF-SA) water quality drinking standards. All analyses for physicochemical parameters were within acceptable limits except for turbidity while microbial loads during spring were higher than the WHO and DWAF thresholds. The detection of *Escherichia coli*, *Salmonella* and *Klebsiella* species in borehole water that was intended for human consumption suggested that water from these sources may pose severe health risks to consumers and is unsuitable for direct human consumption without treatment. The study recommended mobilisation of onsite treatment interventions to protect the households from further possible health consequences of using the water.

Results of this project were published in Palamuleni, L.G. and M Akoth (2015), *International Journal of Environmental Research and Public Health*, Vol. 12, 8619-8630.

The second groundwater study was a PhD thesis *Developing an Integrated GIS-Remote Sensing Methodology for Estimating Groundwater Trends in the Upper Molopo River Catchment, South Africa* done by Mr NN Ndou who was a staff development candidate in the Department of Geography and Environmental Sciences. The aim of the study was to investigate the reliability of GIS and remote sensing techniques in estimating groundwater resource trends using phreatophytic vegetation as proxy for groundwater potential sites. The motivation for this study was justified by the scarcity of surface water coupled with irregular and unreliable rainfall, hence ground water serves as alternative water sources within the semi-arid environments of South Africa. In arid and semi-arid regions worldwide, groundwater plays significant role not only as a source of water for human consumption but also in preserving the ecological value. The semi-arid upper Molopo River catchment (UMRC) is no exception. In this catchment, water shortage was noted and attributed to groundwater level decline caused by poor water resource monitoring and management. Groundwater potential zones in the study area were delineated using Geographical Information Systems (GIS) and Remote sensing (RS) techniques. Implications emerging from the obtained results suggest that GIS and RS can efficiently and reliably provide valuable information regarding potential sites for groundwater in the upper Molopo River catchment, substantial for groundwater monitoring and management purposes. These results also indicate the importance of remote sensing techniques to characterise trends in phreatophyte vegetation condition, potential evapotranspiration rate, and phreatophytic vegetation water potential as surrogate for groundwater levels for informed decisions on groundwater monitoring and management.

The work on this project has the following outputs:

1. PhD candidate graduated in 2017
2. Ndou N.N., Lobina G. Palamuleni, Abel Ramoelo (2018) Modelling depth to groundwater level using SEBAL-based dry season potential evapotranspiration in the upper Molopo River Catchment, South Africa, *The Egyptian Journal of Remote Sensing and Space Sciences* 21 237–248
doi.org/10.1016/j.ejrs.2017.08.003

5. Contribution to Capacity Building

What then are the implications of the schema I have presented in this lecture? My research work since 2002 has cut across both spatial geography and environmental science and, in the process has tentatively touched on several aspects of content covered in this lecture. Outputs of this effort is reported in over 40 papers in international peer-review journals, in over 20 seminar papers, local and international conference papers. My research supervision to date has seen eleven (11) research Masters in the field of both Geography and Environmental Sciences, 9 PhDs in Geography and Environmental Sciences specialising in water-demand management, Ecosystem Provisioning services, water quality for irrigation, spatio-temporal apportionment of water quality analysis while 1 PhD in land use allocation and environmental resource planning is on track to submit the final document for external examination in mid of 2020. Table 2 summarises my supervision thus far.

Table 2: List of PhD and MSc students supervised and graduated

| Candidate | Supervision | Level | Year graduated |
|--|-----------------|-------|----------------|
| Ms Deepa Pullanikkatil (23881356) | Main supervisor | PhD | 2015 |
| Mr Nahom Fajji (22034625) | Main supervisor | PhD | 2016 |
| Mr Naledzani Ndou (17028647) | Main supervisor | PhD | 2017 |
| Mr Frederick Asare (24645095) | Main supervisor | PhD | 2018 |
| Miss Tafadzwa Marara (22082905) | Supervisor | PhD | 2018 |
| Mr Makarati Fidelis (24253537) | Co-supervisor | PhD | 2018 |
| Mr. Khuliso E. Ravhuhali (16144120) | Co-supervisor | PhD | 2018 |
| Mr. Mahasa PS (24009393) | Main supervisor | PhD | 2019 |
| Mr MFL Chagunda (28242270) | Co-supervisor | PhD | 2019 |
| | | | |
| Mr. Nahom Fajji. (22034625) | Main supervisor | MSc | 2011 |
| Ms M. H. Huyser (20728921) | Supervisor | MSc | 2012 |
| Mr. Tabaro H. Kabanda (22638326) | Supervisor | MSc | 2012 |
| Mr Zwidofhelangani Lidzhegu (23229144) | Supervisor | MSc | 2012 |

| | | | |
|------------------------------------|-----------------|-----|------|
| Ms Tafadzwa Marara (22082905) | Supervisor | MSc | 2013 |
| Mr. Sammy Bett (16903781) | Main supervisor | MSc | 2013 |
| Ms. Agnes Turyahikayo (16258433) | Supervisor | MSc | 2015 |
| Ms. Azwifanele Mulugisi (24899623) | Main supervisor | MSc | 2016 |
| Ms. Mercy Akoth (25805657) | Supervisor | MSc | 2018 |
| Ms. Refilwe Matsie (24822469) | Supervisor | MSc | 2018 |
| Mr Iyioluwa Busuyi Raji (27457257) | Supervisor | MSc | 2019 |

6. CONCLUSION

The Department of Geography and Environmental Sciences has since 2010 repositioned itself as a centre of research excellence and impact beyond the immediate North West Province. This has followed a long period of low-key operations in which till 2010 the Department has been transformed through a strategic intervention of recruitment of new staff engaged in teaching, research and community outreach. Through team work, multi-disciplinary applied research, the department offers a platform for problem solving and a skills based approach in various fields of Geography and Environmental across all levels of undergraduate and postgraduate. In the process, we make a contribution in producing graduates that can deploy multiple skills and competences. Challenges still exist in aligning programmes to the “Sustainable Development Goals” and in remaining sensitive to the need for relevance in a rapidly changing economic-driven world. I am proud to belong to a department that has since 2011 appeared at every graduation ceremony to celebrate the achievements of its own students.

6.1. Planned and On-going Research

Madam Deputy Vice-chancellor, colleagues, ladies and gentlemen, how a bridge is build is strongly influenced by the environment in which it is built; how easy is it to build and what materials/technologies are available; the materials used to build the structure etc. In this lecture, I have briefly indicated the materials that can be used to build the land and water bridge which could contribute to a better understanding of land use planning and water resources management. The “so what” bridge has been build and is being built using three broad categories of my research focus: land use and land cover mapping, land use and land cover change focusing on catchment

management and water quality analysis. I have reflected these three components/materials/technologies and for me the special materials include land use mapping, land use planning, water resources management, and catchment management. Understanding of the complex interactions between land and water will strengthen this bridge and probably bring forth the sustainability of both land and water resources. It is in this respect that I hope I have reached out to a wider audience than conventional approaches in the natural and applied sciences would allow; the constructs of multidisciplinary research to answer the complex environmental and human paradoxes of the 21st Century.

Madam Deputy Vice-chancellor, colleagues, ladies and gentlemen, since the bridge is still under construction, monitoring of water quality is definitely a continuous process. I will continue to do the water quality assessment from various water sources. Currently am supervising two MSc students in this area:

- The effectiveness of domestic water treatment technologies, North West Province, South Africa
- Hyperspectral remote sensing of phreatophytic vegetation as a measure of groundwater salinity

In addition, I contemplate the components of the water balance and the implications of surface water availability as the critical areas of my future research activities. To understand water balance and availability, it is therefore important to study the water system i.e. evaporation, transpiration, the rate of evapotranspiration, land use/land cover (LULC) changes and climate variability. These factors ultimately influence water availability as they relate to the hydrological cycle. Currently, one MSc student is involved in this research focussing on: Assessment of Sentinel-2 and Landsat 8 OLI in mapping the spatio-temporal variations of evapotranspiration in the Upper Molopo Catchment area, South Africa. Let me mention here that this arm of my research will have its focal point on the newly launched high resolution satellites to capitalise on their ability to monitor at local spatial scales.

7. ACKNOWLEDGEMENTS

Madam DVC, colleagues, ladies and gentlemen, before I end my lecture, I would like to thank the Almighty God who has been the source of wisdom to me. I am grateful because of the power of His words, most especially the inspiration in the book of James 1 vs 5 *If any of you lacks wisdom, you should ask God, who gives generously to all without finding fault, and it will be given to you;* Zechariah 4 vs 6 *So he said to me, "This is the word of the LORD to Zerubbabel: 'Not by might nor by power, but by my Spirit,' says the LORD Almighty.* To Him alone be the honour and the glory. I appreciate the Pastors and members of Living Waters Church in Zomba, Malawi; Discipleship Ministries Mafikeng and Great Grace Bible Church, Mafikeng for always reminding me that: *The fear of the Lord, is the beginning of wisdom.* Pastor Moses Tlalang, thank you for accepting to bless this ceremony.

I would like to thank the management of the North-West University, Mafikeng Campus for giving me the opportunities to express my academic and research potentials. I am eternally grateful to the former Campus Rector Prof Mashudu Davhana-Maselesele who at the time of my interview for the academic position at the North West University was Acting Dean in the then Faculty of Agriculture, Science and Technology. The last question she asked me during the interview: *“have you ever supervised any post graduate student?”*, made me realise that as an academic one of the fundamental requirements is supervision. That question keeps lingering in my mind and am sure it is one that has made me to stand before you today. Prof Eno Ebenso, thank you for always believing in me even in those moments I strongly doubted myself. Special thanks to the management of this great institution under the leadership of Prof D Kgwadi, Prof M. Setlalentoa (DVC, Campus Operations Mafikeng) and all colleagues in the Faculty of Natural and Agricultural Sciences and the entire North West University community for the support and in creating an enabling environment throughout my stay here in Mafikeng. Special acknowledgement to all colleagues in the Department of Geography and Environmental Sciences, Mafikeng Campus, past and present, for making me who I am today.

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As you know, success and achievement have many parents, and I would like to thank all of the teachers, mentors and friends who have shaped and encouraged me over my personal, as well as my professional, life. To my best friend Mrs Flora Mpazanje who in 1998 whispered into my ears words of encouragement when I was going through the darkest and lowest moment of my life. Those words made me to rise up and see the world from a different perspective. Am sure, they were a catalyst to my standing in this position today. I should also mention my friend Dr Juliet

Kamwendo who over the past 26 years has transitioned from my neighbour to be my sister. Thanks for always being there to share my joys, laughter and pains. You are a good listener!!

I need to mention the contribution made by the late Lewis Jonker, the chairperson of WaterNet in 2001 who was instrumental in making sure that I attend my first international which was organised by the University of the Western Cape. He made sure that I travel with my two months old baby, and organised nursery care for her. The result of the conference was my first publication which has since 2002 received global recognition in terms of citations (70 plus) and numerous downloads. To my students who remain a source of delight in my interactions with them. To my fellow researchers, supervisors and collaborators who make life quite interesting. Madam Deputy Vice-chancellor, I am honoured to have been given the opportunity to serve this university.

I would like to express my sincere thanks to all my collaborators within South Africa and beyond its borders. To the postgraduate students who were willing to work with me and friends who have supported my academic career in various ways.

I thank you all for patiently listening to me this evening. May the Lord Almighty grant you journey mercies as you travel back to your respective homes.

Zikomo kwambiri

Thank You!

Dankie!

Kealeboga!

Asante Sana!

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